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Front cover: *Olearia pannosa* subsp. *pannosa*. Photo: Peter Watton.

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Australasian Plant Conservation is a forum for information exchange for all those involved in plant conservation: please use it to share your work with others. Articles, information snippets, details of new publications or research and diary dates are welcome. General articles on any plant conservation issue are most welcome.

The deadline for the **June to August 2019 issue is 1 May 2019**. The special theme for the issue is **translocation of threatened plants**. If you are intending to submit an article or wish to discuss possibilities, please email the editor, Heidi Zimmer: **editor@anpc.asn.au**.

Authors are encouraged to submit images with articles or information. Please submit images in electronic format, resolution needs to be at least 300 dpi, at least the size that they are to be published, in tif, jpg or gif format. Guidelines for authors and an article template are at: **http://www.anpc.asn.au/apc**.

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From the editor

HEIDI ZIMMER

The theme of the 12th Australian Plant Conservation Conference (APCC12), held in Canberra in November 2018, was 'Moving house: A new age for plant translocation and restoration'. In this issue of Australasian Plant Conservation we sample from the diversity of topics from APCC12.

We begin with Margaret Byrne's article detailing a phylogeographic analysis of southern Australian plants, which suggests many species have climatic tolerances broader than the environments in which they currently exist. She urges us to consider climate change when choosing provenances for restoration, and select seed from hot dry environments to harness species adaptive capacity. Also on the climate change theme, John Patyowski and others write of the opportunity in restoration to expand species ranges, such as by planting species at the edges of their currently suitable habitat – potentially increasing the chances of restoration success. Next, Amelia Hurren and others describe some of the first results of a project which aims to increase the adaptive capacity of *Olearia pannosa* subsp. *pannosa* in response to changing climate. They find that the plants at the edge of the geographic range indeed appear stressed, and suggest a climate-adjusted composite provenancing strategy.

Next, we shift our focus to seeds, as Fernanda Caro Beveridge *et al.* describe the importance of analysing seed quality indicators (*e.g.,* seed fill) and use of seed enhancement (*e.g.,* pre-treatments, hydro-priming, modification of seed shape) to improve seed-based restoration outcomes. Continuing on the topic of seeds, Megan Hirst and others tell us of their work on Victoria's rare and threatened wildflowers: testing seed viability and germination of 22 species. They link the varying responses to species' wild origins and seed lot qualities. They also discuss the role that markets (to conservationists and plant collectors, as well as traditional ornamental horticulture) may play in conserving these species. We then move to a story of restoration in action, where Eddy Wajon and Julia Cullity consider the factors affecting tubestock survival at Ken Park.

Bryan Haywood then tells the story of how an ecological burn has resulted in flowering, seeding and germination of the federally listed Critically Endangered *Cassinia tegulata.* This is followed by an article by Matthew Pearson describing the management of *Allocasuarina robusta*, and the importance of considering genetics in translocation programs.

In a change of gear we shift our focus to biosecurity; another key issue for securing the future of Australia's native plants. Franciso Tovar and Angus Carnegie give a detailed overview of Australia's biosecurity program, with a particular focus on forest pests. This provides an excellent segue into Bob Makinson's article, which illuminates us on the threat that Myrtle Rust poses to Australia's Myrtaceae and the challenges of inspiring national action.

In regular features we have: news from the Australian Seed Bank Partnership, which focuses on the *ex situ* conservation session at APCC12; two ANPC workshop reports, on the field day in the Upper Hunter and a translocation workshop in WA; a profile of ANPC corporate member Rob Scott, Director of Naturelinks Landscape Management; book reviews on the 'Allure of Fungi' and 'Australian Forest Woods'; ANPC news and conferences; and research round up. Thank you to everyone who contributed to this bumper issue!

Moving plants – revealing the past and informing the future

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Introduction

Changing climate has led to calls for implementation of adaptation strategies to ensure ecosystem resilience. Assisted migration is advocated for movement of species outside their current range when current climate becomes unsuitable. Assisted *gene* migration (Aitkin *et al.* 2013) and climate adjusted provenancing (Prober *et al.* 2015) have been advocated as strategies for moving germplasm within species to improve the resilience and adaptive capacity of key species in ecosystems spanning climate gradients.

These climate adaptation strategies require a solid evidence base for implementation in conservation and ecosystem management. Genetic analysis can provide evidence to support or refute these climate adaptation strategies, both in terms of understanding historical responses to climate change, and in assessing signals of adaptive capacity in current distributions.

Change in climate and environment lead to change in distribution and interactions among species, and subsequent change in genetic diversity and differentiation/structure. Genetic signatures differ for localised persistence (high haplotype diversity and high population differentiation), contraction to macro refugia (high diversity), and range expansion (low haplotype diversity and population differentiation).

Phylogeography

Phylogeography is the study of geographical distributions of genealogical lineages, and inference of biotic responses. In plants, chloroplast DNA is slowly evolving, generally maternally inherited (paternal in gymnosperms), and does not undergo recombination, and so can be used to give a look back into evolutionary history.

Phylogeographic analysis has identified examples of localised persistence in many species through the Pleistocene (2.8 million to 20,000 years ago), such as *Santalum spicatum*, *Acacia acuminata*, and *Eucalyptus loxophleba* (Byrne *et al.* 2002, 2003; Byrne and Hines 2004) that occur in semi-arid areas. These species all show high haplotype diversity and differentiation among populations with coalescence of haplotypes at 0.7 to 1 million years ago at a time of major aridification and development of sandy deserts.

In more mesic areas, studies also reveal similar patterns of localised persistence in forest and overstorey species, eg. *Kennedia coccinea*, *Bossiaea ornata*, *Allocasuarina humilis*, and *Corymbia calophylla* (Bradbury 2015a, b; Llorens *et al.* 2017; Sampson *et al.* 2018). These species also show some evidence of expansion in wetter southern most areas, although this expansion is historical and likely occurred with drying climate over later climatic cycles in the Pleistocene.

We see some signal of contraction to refugia and subsequent expansion in *Calothamnus quadrifidus* and *Eucalyptus wandoo* (Nistelberger *et al.* 2014; Dalmaris *et al.* 2015), but this expansion occurred ca. 300,000-400,000 years ago and does not represent recent expansion since the last glacial maximum (LGM, ca. 20,000 years ago).

Analysis of these patterns allows inferences of past evolutionary history to be drawn. Localised persistence is a major response of biota to historical climate change, indicating the importance of local climatic conditions and mosaic of habitats in heterogeneous landscapes. It also suggests species have broad fundamental niches and can tolerate wide climatic conditions, or that persistence across their distribution through the Pleistocene has allowed adaptations to develop.

Signals of adaptation to climate

New powerful genomic technologies can also provide evidence for signals of adaptation. Adaptation to climate was investigated in three widespread eucalypts distributed across climatic gradients using genome wide screening and outlier analysis (Steane *et al.* 2014, 2015, 2017). This program of works also investigated morphological (leaf size, thickness, tissue density) and ecophysiological traits (isotope ration, N content, water use efficiency) in these species (McLean *et al.* 2014; Steane *et al.* 2015, 2017). Signals of adaptation evident through correlation of genomic loci with climatic variables were found in all three species (Steane *et al.* 2014, 2015, 2017). Signals of adaptation were also found in a key forest tree in south west mesic region, *Corymbia calopyhlla* (Ahrens *et al.* revision submitted) with change in allele frequency matching change in values of climate variables for temperature, precipitation and aridity index over short geographical distances.

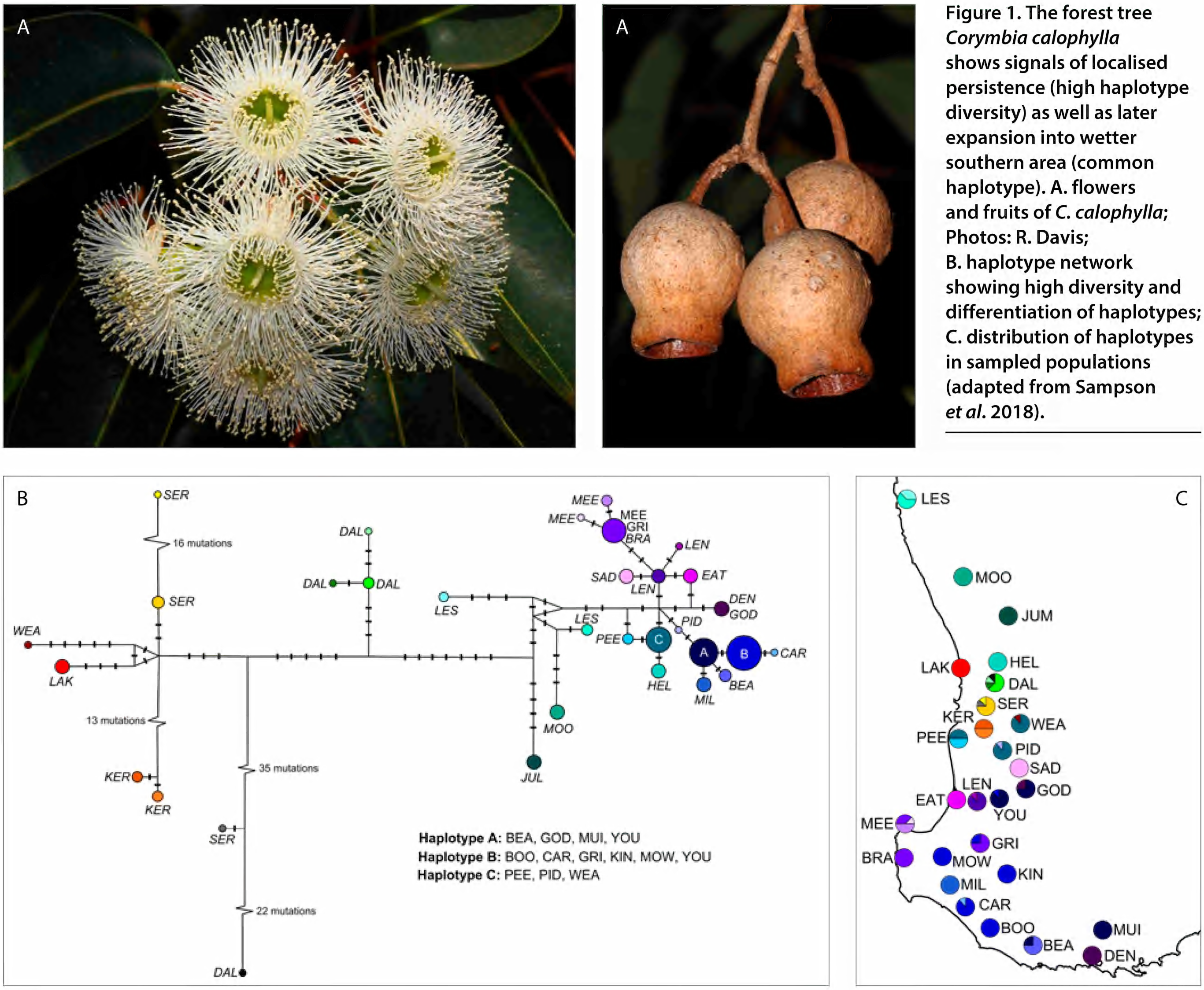

Figure 1. The forest tree *Corymbia calophylla* shows signals of localised persistence (high haplotype diversity) as well as later expansion into wetter southern area (common haplotype). A. flowers and fruits of *C. calophylla*; Photos: R. Davis; B. haplotype network showing high diversity and differentiation of haplotypes; C. distribution of haplotypes in sampled populations (adapted from Sampson *et al*. 2018).

Implications for management of species

Phylogeographic analysis of plants in southern Australia reveals multiple levels of divergence and complex structuring. These genetic signatures of high diversity and endemism indicate persistence of the biota through climatic oscillations over multiple glacial cycles as a major response to changing climatic conditions. Persistence of populations across the distribution through time indicates that species may have wider climatic tolerance than is implied by their current distributions.

Knowledge of species responses to historical climate change suggests migration to track an ecological niche is not a likely response to future climate change (even if there was habitat continuity) and future persistence of biota will be facilitated by maintenance of dynamic evolutionary processes, a mosaic of habitats in heterogeneous landscapes and conservation of genetic variability and adaptive potential.

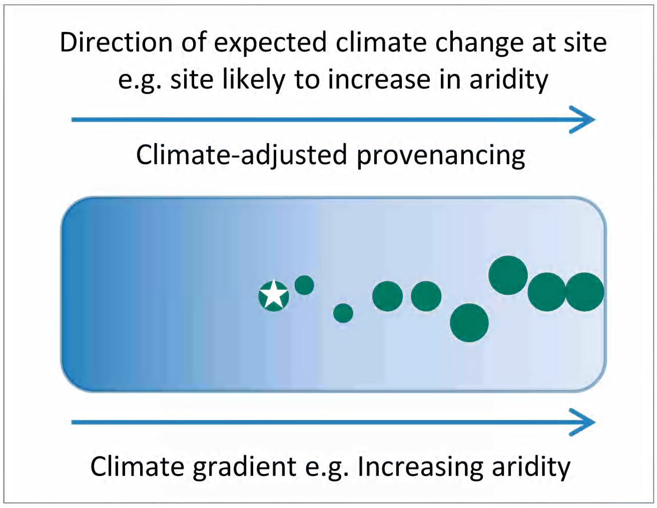
Direction of expected climate change at site
e.g. site likely to increase in aridity
Climate-adjusted provenancing
Climate gradient e.g. Increasing aridity

Figure 2 .Signals of adaptation across climatic gradients in widespread eucalypts support a climate adaptation strategy for seed sourcing. The star represents the restoration site; green circles represent seed collection sites; background colour gradient represents a climate gradient (adapted from Prober *et al*. 2015).

Genomic analysis in widespread plants distributed across climate gradients reveals signatures of adaptive capacity in most species, with evidence of genetic adaptation to temperature and/or rainfall. This adaptive capacity can be harnessed by moving seed from hot dry environments into less harsh environments ahead of climate change to increase the frequency of adaptative genes in populations to cope with more arid conditions. Genetics analyses support a strategy of climate adjusted provenancing where seed for restoration is sourced from populations across the climate gradient in the direction of changing climate. In this way the adaptive variation and capacity for plasticity is captured and introduced to populations in advance of changing climates.

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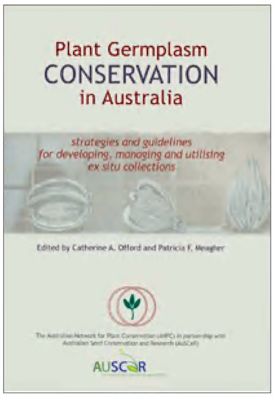
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Using tree physiology to aid land-management decisions in a changing climate

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Climate change and global vegetation shift

As global weather patterns shift under a changing climate, parts of Australia will experience higher maximum temperatures as well as more frequent and intense droughts (Collins *et al.* 2013). As a result, plants at the limit of their climatic range will experience shifts in their distribution, changing the composition of vegetation communities (McDowell and Allen 2015). We can model how species may respond to climate change based on their current distribution, as well as relationships with current and predicted future climates; but often the realised niche of a species is a subset of its fundamental niche due to competition with other species. Changes in climate will affect interactions among species, thus comparative physiology is a promising way to predict future interactions. Dominant trees often characterise vegetation types and strongly influence ecosystem functioning. Predicting interactions among dominant species is important for understanding the capacity of future ecosystems to perform key functions, and determine how we might manage ecosystems if changes to climate result in loss of functioning and broader impacts on ecosystems.

Understanding species responses to climate change

Many studies explore the effects of elevated temperatures, increased atmospheric CO_2, and drought on native species and competitive interactions, often using physiological parameters such as photosynthetic rate, stomatal conductance, and instantaneous water-use efficiency as an objective measure of inter-specific comparative performance (e.g. Morris *et al.* 2011). Broadly speaking, the response of plants to changes in their growing environment are species-specific, even for those commonly occurring in the same ecological communities; thus, future competition between these species is likely to change over the long-term (Duan *et al.* 2013). For example, *Eucalyptus* forests in Australia face an uncertain future. Interactions between drought-stress and increased temperatures can suppress photosynthetic performance of *Eucalyptus* seedlings, but elevated CO_2 can ameliorate these effects in some species (Lewis *et al.* 2013) and previously subdominant species can become more competitive in the future (Rawal *et al.* 2014). Typically, such studies involve greenhouse experiments using juvenile plants; studies comparing co-occurring species are limited, especially concerning mature individuals *in situ*.

Planning for functional stability in land restoration through assisted migration

Given inevitable climate change, it is important that we consider how land restoration should look in the immediate future. Typically, restoring land focuses on replicating presumed former communities based on predicted distributions and affinities with habitats. Although this is an appropriate measure, we need to think in terms of decades-to-hundreds of years when considering the role of long-lived species such as canopy trees in performing ecological functions. Understanding which species may lose or gain suitable habitat could give us a chance to speculatively plant novel combinations of canopy species such that ecosystem processes can be maintained under fluctuating environmental conditions because of trait-redundancy between species. For example, conditions that are detrimental to the presence of a common species in a system also may confer a competitive advantage to a functionally similar, less common species (McNaughton 1977). Research in this field is in its infancy compared to other areas of ecology, so real-world data and experiments seeking to test these ideas are of importance.

A central Victoria case study

In a recent experiment (Patykowski *et al*. in review), we compared rates of photosynthesis, stomatal conductance, and transpiration among six co-occurring *Eucalyptus* species in a box-ironbark ecosystem in southeast Australia (Heathcote-Graytown National Park, Victoria). We measured these physiological parameters in each of four seasons over a 12-month period (March 2015 - January 2016) during a year of severe water-deficit (299.2 mm during the study period, compared to 594 mm average rainfall from 1961–1990; Bureau of Meteorology 2019). Field measurements were taken from established trees (> 30 years old) in their natural habitat, using a portable infra-red gas analyser (ADC Bioscientific LC Pro-SD). These measurements were used to infer competitive ability through productivity (photosynthetic carbon assimilation) and drought tolerance (stomatal conductance and water-use). We measured these parameters under maximum light irradiance (2000 µmol photons of photosynthetically active radiation m^{-2} s^{-1}) from three leaves per tree, five trees per species, and six species across four seasons. We compared means among species using analysis of variance. Of the six species, *Eucalyptus melliodora* displayed the lowest rates of photosynthesis, stomatal conductance of H_2O (mol m^{-2} s^{-1}) and transpiration ($P < 0.001$; Figures 1-3). If droughts become more common its competitive ability may be reduced such that it disappears from parts of its current range. Conversely, *Eucalyptus goniocalyx* displayed the highest rates of photosynthesis relative to stomatal conductance and transpiration, which might make it better adapted to cope with frequent drought and warmer temperatures in the region we studied. Species with a high tolerance to stress may generally be less competitive under optimum conditions in a community, but may become highly competitive when resource limitation suppresses the competitive ability of more common species (Liancourt *et al.* 2005). *Eucalyptus goniocalyx* may, therefore, be at a competitive advantage under extreme drought in comparison to other species in the community. Conversely, species such as *E. melliodora* that are predominantly restricted to gullies and ephemeral drainage lines within the study region could be competitively excluded by other species from this forest due loss of suitable micro-habitats under a drying climate.

Discussion

Physiological differences among co-occurring mature trees can indicate how they will interact and compete in the future. In selecting species for land restoration, consideration should be given to predicted future climates, the formation of novel communities and assisted migration of species at the thresholds of currently suitable habitat. Revegetation offers an excellent opportunity to establish plants outside of, or on, the periphery of their current range, in anticipation of these areas becoming more favourable in the future. Such planting must be coupled with good experimental design to measure impacts on ecosystems; there is an urgent need to build upon the foundation of this research area, mixed with a better understanding of phylogeography, reproductive biology and other fields of ecological research. By expanding species' ranges we could offer ecosystems functional insurance against the loss of species and the ecosystem services they provide. By doing so, we stand to enhance the long-term success of both species conservation and land restoration efforts, thereby promoting long-term functional stability in ecosystems.

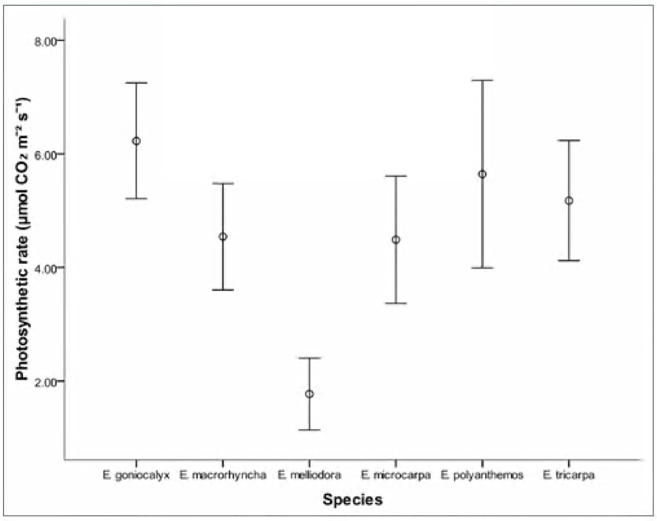

Figure 1. Mean ± s.e. photosynthetic rate of six *Eucalyptus* species from central Victoria under light saturation across four seasons (autumn, winter, spring, summer).

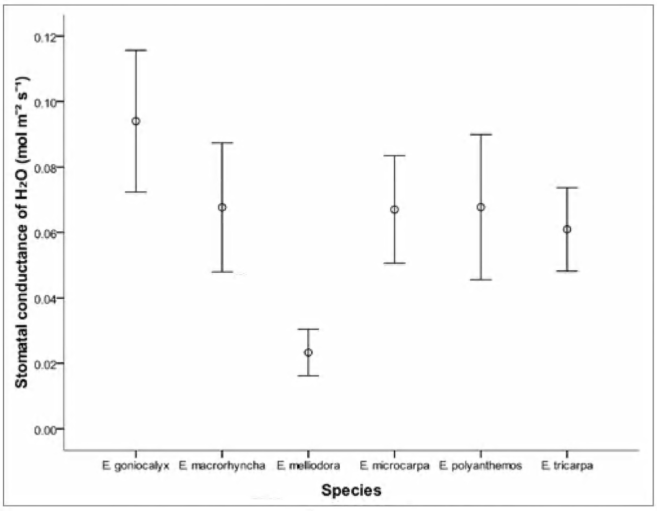

Figure 2. Mean ± s.e. stomatal conductance of six *Eucalyptus* species from central Victoria under light saturation across four seasons (autumn, winter, spring, summer).

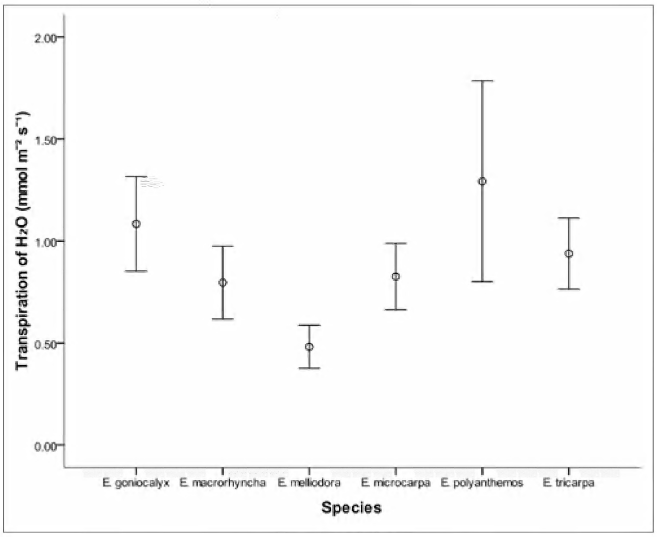

Figure 3. Mean ± s.e. transpiration of six *Eucalyptus* species from central Victoria under light saturation across four seasons (autumn, winter, spring, summer).

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Community action across South Australia to secure the future of the Silver Daisy bush in a changing climate

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Summary

Olearia pannosa subsp. *pannosa* (Silver Daisy), is a federally-listed Vulnerable species as well as a priority species in the Australian Government's Threatened Species Strategy, and is listed as Vulnerable in South Australia. In 2018, conservation organisation 'Trees For Life' received Threatened Species Recovery Hub funding to implement a project entitled 'Community action across South Australia to secure the future of Silver Daisy Bush in a changing climate'. Here we report on progress to date and future actions aimed at increasing the resilience of the species.

The species

Olearia pannosa subsp. *pannosa* is widely distributed across South Australia from the Eyre Peninsula (EP) to the Southern Flinders Ranges (SFR) and down to the Fleurieu Peninsula (FP) and South East (SE) of the state. Another subspecies, *Olearia pannosa* subsp. *cardiophylla* (Velvet Daisy Bush), has a partially overlapping distribution across much of the South Australian range of *O. pannosa* subsp. *pannosa* and into Victoria. *Olearia pannosa* subsp. *cardiophylla* is not federally-listed, but is listed as Vulnerable in Victoria. Threats to both sub-species include small and fragmented populations, grazing pressure, habitat clearance (especially roadside populations) and weed invasion. *Olearia pannosa* is known to reproduce sexually and clonally (by suckering), the latter potentially reducing the long-term genetic diversity and therefore resilience of the species, particularly in the face of climate change.

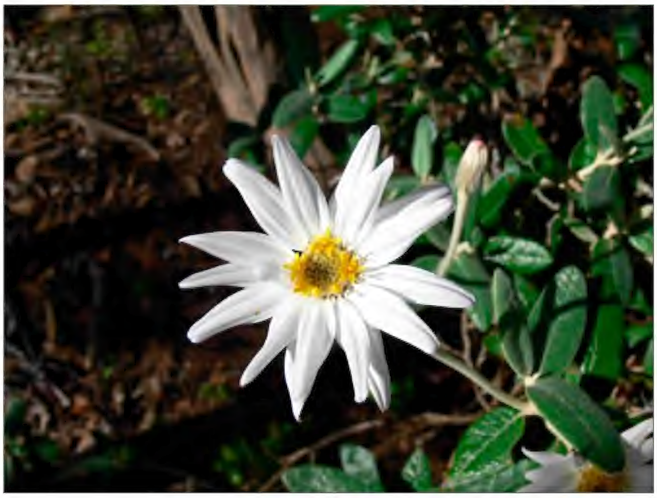

Figure 1. Silver daisy *Olearia pannosa* subsp. *pannosa*. Photo: Peter Watton.

The project

We aim to bolster the adaptive capacity of *O. pannosa* subsp. *pannosa* to a changing climate by increasing the genetic diversity within remnant populations, establishing new populations in suitable future climate envelopes, and ensuring that genetic material from at-risk populations is conserved.

To achieve this aim our project will:

- Characterise the genetic diversity and structure of *O. pannosa* subsp. *pannosa* to inform our seed provenancing strategy for translocations.
- Use habitat suitability analysis to assess populations most at risk from changing climatic conditions and identify future suitable climate envelopes.
- Address key threats to priority remnant populations.
- Increase our understanding of the validity of the two sub-species.

Activities to date

We visited populations across the range of both sub-species to collect leaf tissue and seed samples, assess the size and status of populations, and determine threat abatement actions. We worked closely with staff from six Natural Resources Management Boards (EP, Northern & Yorke (NY), Adelaide & Mount Lofty Ranges (AMLR), Kangaroo Island (KI), SA Murray Darling Basin (SAMDB) and SE). We also worked with other organisations, community groups and individuals, including land managers and we documented at least two new populations.

Genetic analysis was conducted on 191 samples from 17 spatially separate locations across the distribution of both sub-species, with samples from Victoria being provided by colleagues at Trust For Nature and Victoria's Department of Environment, Land, Water & Planning. Sampling avoided nearest neighbour plants to reduce the risk of collecting closely related individuals. Our partners at the University of Adelaide undertook population genomics analysis and conducted genome scans of samples of both sub-species to assess their levels of genetic diversity, genetic differentiation between sampling locations and subspecies, and to assess the levels of inbreeding and clonality within locations.

Habitat suitability modelling will be conducted in the next phase of the project. We have used coarse climate projections to predict a southerly directional change in climate and a consequent south-ward range contraction of silver daisy.

Results

The genetic analysis showed that most of the South Australian plants were closely related, with evidence of historical gene flow across the entire distribution of *O. pannosa* subsp. *pannosa*. While Victorian samples were genetically distinct from South Australian samples, they showed evidence of historical genetic connectivity with SA samples and were most closely related to plants from the South East of SA.

Genetic differentiation across the range of *O. pannosa* subsp. *pannosa* was consistent with an isolation by distance pattern, where samples in close geographic proximity were genetically more similar than geographically distant samples. This pronounced pattern was likely reinforced by a reduction in gene flow across its range as a result of habitat fragmentation and reduced population size.

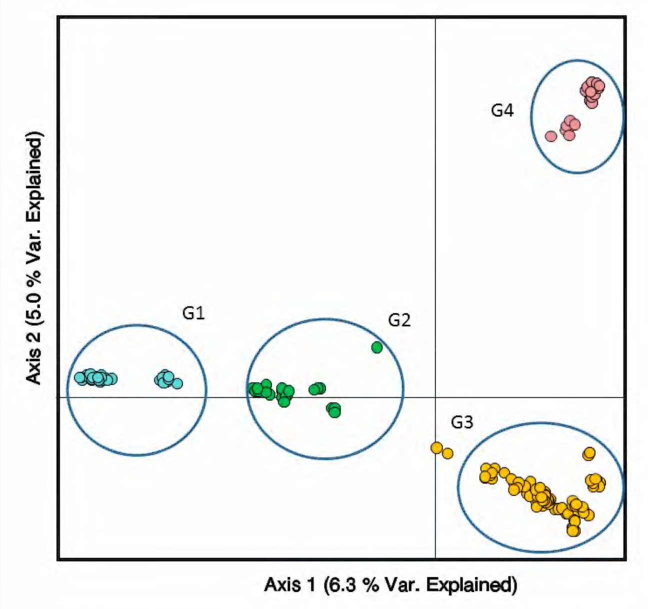

Figure 2. *Olearia pannosa* genetic structure, displaying 4 distinct genetic clusters. Colours represent sampled regions. G1 = Victorian samples; G2 = South-east of SA; G3 = SA Complex (EP, Yorke Peninsula, SAMDB and AMLR); G4 = SFR (subsp. *cardiophylla* samples).

The exception was plants sampled from the southern Flinders Ranges which were strongly genetically differentiated from all other samples.

The overall pattern of these genetic results suggests that although plants sampled in the majority of SA and Victoria were most likely *O. pannosa* subsp. *pannosa*, those from the Flinders Ranges were likely *O. pannosa* subsp. *cardiophylla*.

Surprisingly, weeds were not identified as a significant threat across the range of this species, as initially expected. Similarly, there was no evidence for population-wide clonality. However, inbreeding was relatively high across the range. The level of inbreeding depression is not known but is a risk for fragmented populations and is likely to reduce the fitness and capacity of populations to adapt to environmental change.

Future work

Olearia pannosa subsp. *pannosa* is a widely distributed species that occupies a broad climatic envelope. Our fieldwork suggests that plants at the edge of the geographic range in the north and west appear less vigorous and showed more signs of climate stress, such as little fresh growth or seed set. We assume a southerly shift in temperature and rainfall will occur with climate change, which is likely to result in a subsequent shift in suitable climate envelopes. We therefore propose a climate-adjusted composite provenancing strategy for this species, with the aim of increasing the genetic diversity and ability to adapt, mitigating the high levels of inbreeding, and establishing populations with the genetic diversity likely to be pre-adapted to future climate change conditions. We propose including some local provenance as well as more northerly provenances to retain local adaptation while bringing in more genetic diversity to increase the adaptation potential.

Conclusions

The application of genome-wide genetic information has been very useful in clarifying the genetic character of *Olearia pannosa* and guiding our provenancing strategy. It has also raised questions about the taxonomy and conservation status of both *O. pannosa* subsp. *pannosa* and *O. pannosa* subsp. *cardiophylla*. *Olearia pannosa* subsp. *pannosa* may be nominated in future for de-listing from the *EPBC Act*, but our data suggest that *O. pannosa* subsp. *cardiophylla* might meet the criteria for listing in its place, given its very restricted distribution. Taxonomic work is needed to clarify the sub-species relationships before this occurs.

Despite the genetics data and a relatively conservative provenancing strategy proposed here, there has been some discomfort expressed towards our recommendations. Local conservation groups have been advised for many years that local provenance (i.e. plants sourced <20 km from a planting site) is best, and that bringing in non-local provenance may result in outbreeding depression or genetic swamping. Based on our recent research, the risk of either outbreeding depression or genetic swamping is extremely low, and is further unlikely based on the close genetic similarity between plants across SA. Indeed, not enhancing the genetic diversity of remnant populations is a much greater risk for these populations as they begin to face changing environmental conditions and small population effects of reduced adaptive potential. We will establish a common garden provenance monitoring project to track survival and success of five different provenances at one site, and conduct a community communication program to promote the basis for the decisions recommended in this work.

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Seed enhancement of Australian native species to improve seed-based restoration

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Introduction

Direct sowing of seeds (i.e. seed-based restoration) is an approach by which a previously cleared plant community can be re-established. The use of seeds is particularly important when restoration occurs over large areas. Using seed as the plant propagule to restore indigenous biodiversity and ecosystems within disturbed landscapes should be a cost-efficient and highly scalable method. However, many different factors influence seed-based restoration, and often restoration is done in ecosystems that have not been well characterised (Merritt and Dixon 2011). Thus, for seed-based restoration to be successful, it is critical to have appropriate knowledge of each species ecological requirements for germination and establishment. The development of such knowledge could significantly improve the restoration of threatened ecosystems.

Challenges to seed-based restoration

Environmental factors

For seeds to be used in an effective and successful manner, many edaphoclimatic challenges need to be overcome when undertaking ecological restoration of indigenous plant communities. Australian soils are characterised by being highly eroded and nutrient deficient, commonly exhibiting high salinity and sodic conditions. Moreover, climatic conditions (temperature and rainfall patterns) across the continent can be highly variable and unpredictable, adding to the challenging nature of restoration. Seedling emergence can be delayed by unpredictable rainfall events and hindered by high temperatures and poor soil conditions. Furthermore, several other environmental pressures can negatively affect restoration outcomes, including seed removal or predation by animals such as ants or birds, the grazing of seedlings by native and domesticated animals, and competition from weeds.

Seed factors

Several abiotic and biotic factors influence the success or failure of revegetation projects, even when attempts have been made to overcome such factors. Low and unpredictable seedling establishment is commonly seen in seed-based restoration practices even when the best information is available (Merritt *et al*. 2016), with seed losses exceeding 90% in biodiverse restoration programs (Williams *et al*. 2002). Two main barriers identified in the plant recruitment cycle are: 1) seed factors including seed fill, viability, vigour and dormancy status, and; 2) seedling factors including emergence rate and speed and rate of establishment (Figure 1). To overcome these barriers, a thorough understanding of the seed ecology of the plant species being used is needed, together with details

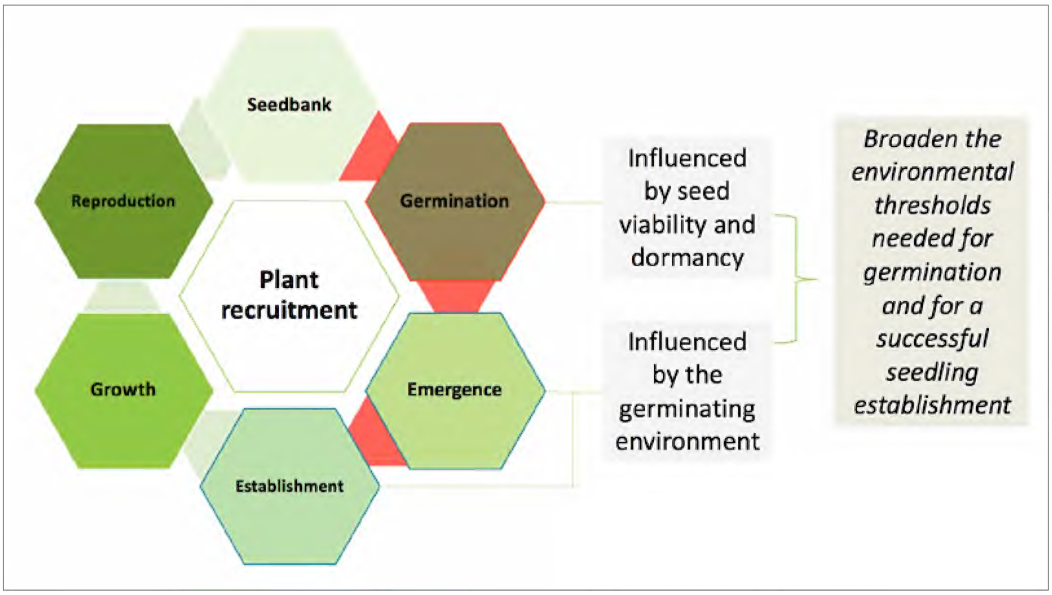
Seedbank
Reproduction
Germination
Plant recruitment
Growth
Emergence
Establishment
Influenced by seed viability and dormancy
Influenced by the germinating environment
Broaden the environmental thresholds needed for germination and for a successful seedling establishment

Figure 1. Plant recruitment cycle. Two main limitations to plant recruitment can be identified; the first is seed germination, influenced mainly by seed fill, viability and the presence of dormancy. The second is seedling emergence and establishment, mainly influenced by the environmental conditions present at the restoration site. Diagram adapted from Merritt *et al*. (2016).

of the germination environment that will be present at the site being restored. If edaphoclimatic barriers to seedling establishment present at the disturbed site are correctly identified, then correct site management can be conducted to ensure appropriate conditions for successful plant community establishment.

Seed enhancement

Seed pre-treatments

To broaden the environmental limits that will promote germination and overcome seed dormancy, seeds can be pre-treated by several means before sowing. Such methods include the use of chemicals such as oxidizing agents, growth regulators, and smoke-derived chemicals to stimulate germination, or the application of hot water, scarification, or enzymes to weaken seed coats and overcome dormancy. The aim of such seed pre-treatments is to mimic the environmental conditions that seeds experience while they are stored on the soil surface or in the soil seedbank that promote germination, and apply these to seed before being used in restoration projects (Merritt *et al*. 2007; Commander *et al*. 2009).

Seed enhancing technologies

Besides pre-treating seeds, the use of seed enhancing technologies (SET) can be used to overcome different limitations to plant recruitment. SET can be defined as a set of different methods applied to the seed after it is harvested that promote seedling growth and establishment, protect seeds from predation and improve seed handling and sowing (Merritt *et al*. 2016). These techniques have been widely used for agricultural and horticultural crops, but have not received similar attention to enhance the performance of native species. However, they have gained more recent attention to overcome restoration limitations, such as the facilitation of seed broadcasting, timing and enhancing of germination and increasing soil water availability to seed (Madsen *et al*. 2013).

The benefits of adopting these techniques can be seen in the seed at a physical and physiological level. Seeds can be hydro-primed, which consists of a pre-hydration and posterior dehydration before radicle protrusion occurs. The aim is to initiate metabolic activities within the seed that will help provide faster and more uniform germination and seedling emergence. Chemicals such as gibberellic acid can also be added in the priming process to help break dormancy. On the other hand, SET can also be used to physically modify the seed structure by coating or pelleting them (Figure 2). This is particularly useful for Australian native seeds as it is very common for seed from the same species or from the same plant to exhibit a broad range in size and morphology, which can make handling seed very complicated and inefficient.

In addition to modifying seed shape, different chemicals can be added to the coating ingredients, for example, those that can stimulate germination and enhance seedling establishment (phytoactive promotors) such as smoke water, gibberellic acid, potassium nitrate and ethylene (as ethrel). Additional chemicals include other plant growth regulators, microorganisms to promote seedling nutrient uptake, agrochemicals such as herbicides and pesticides, nutrients and soil surfactants (Madsen *et al*. 2013). Many of the enhancing chemicals used in SET are the same ones that can be used for seed pre-treatment. Therefore, a combination of pre-treatments and SET should be considered to achieve optimal outcomes. SET could be applied to seeds that have already been pre-treated, to tackle site-specific problems, such as hard crusting sodic soils, heavy weed competition, or hydrophobic soils (Madsen *et al*. 2013).

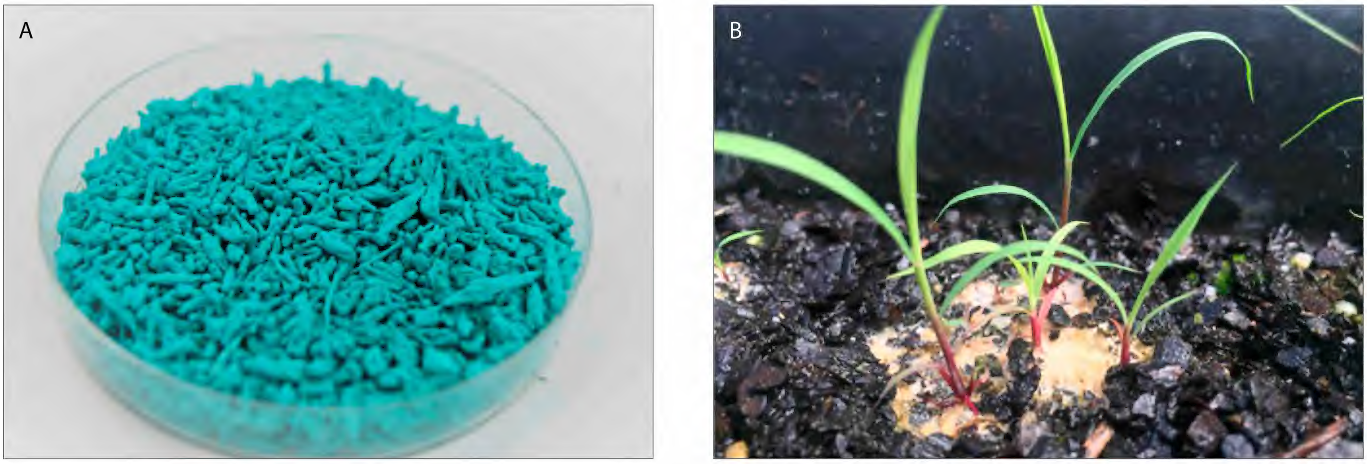

Figure 2. Seed enhancing technologies. A. Coated seeds of *Cymbopogon refractus* (R. Br) A. Camus. B. Seedlings emerged from a seed cookie (*C. refractus, Capillipedium spicigerum* S.T. Blake and *Bothriochloa bladhii* (Retz.) S.T. Blake). The coating and cookie were made with bentonite, calcium carbonate and a binder polymer; potassium nitrate and smoke water were added as enhancing chemicals. Photos: Fernanda Caro

Further studies are required to investigate how phytoactive chemicals can be delivered to the seed. If primed, the seed immediately contacts and absorbs priming chemicals. If coated, the phytoactive promotors are only added to the seed surface. Then the chemicals will only be available to the seed when irrigation or rainfall provides enough moisture to dissolve them. Moreover, for species which present similar dormancy mechanisms and need the same cues to break it, seeds could be bulked and seed mixes treated at the same time (Merritt *et al*. 2016).

Conclusions

In recent years, more attention has been given to the use of native species in the revegetation of Australian natural landscapes; however, little effort has been placed on the use of seed enhancement approaches to improve seed-based restoration outcomes. To achieve this in a cost-efficient manner, further research is required regarding the seed ecology and biology of plant species native to the different degraded habitats that need restoration.

By analysing indicators of seed quality, such as seed fill, viability, germination, dormancy and longevity, seeds can be used in a more efficient way. Importantly, this must be related to the correct identification of the thresholds present in the environment limiting successful restoration. Following on from this is the use of pre-treatments and seed enhancing technologies to improve seed germination and seedling emergence.

Species-, dormancy- and site-specific techniques should be developed to enable these technologies to be used in the most efficient way possible. It is critical that research focuses on techniques that are replicable in large-scale restoration programs where hundreds of thousands of seeds are to be sown across large land areas. Only then will Australia be one step closer to recovering its natural environment.

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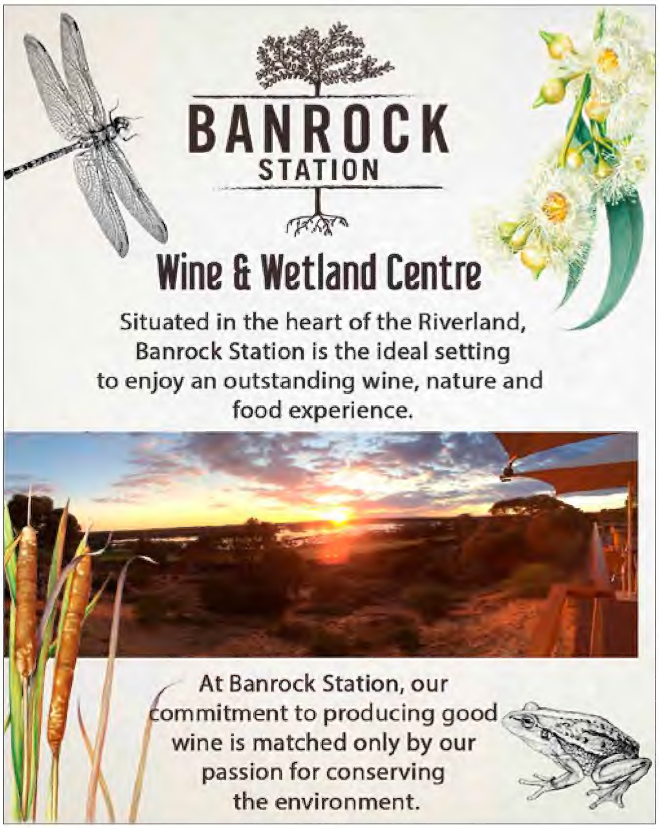

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Raising rarity: horticultural approaches to conserving Victoria's rare and threatened wildflowers

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Background

Conservation horticulture aims to retain genetic and phenotypic variation present in natural populations, while commercial production seeks a uniform product, often through clonal propagation or the use of highly selected seed. While the efficiencies of large-scale commercial horticultural production provide obvious opportunities to save rare and threatened plants, the challenges of plant production have to be addressed, bearing in mind that selection of plant material or propagules from a limited range of sources may further compromise at-risk species (Winter and Botha 1994). As a key role for botanic gardens is to make the public aware of the need for plant conservation (Convention on Biological Diversity nd), it is logical to trial a conservation project for rare and threatened Australian forb species in collaboration with the Royal Botanic Gardens Victoria (Cranbourne). We will use this opportunity to raise awareness of the importance of conservation horticulture, and the sometimes-conflicting aims of ornamental plant production. There is no doubt that the public has an appetite for endangered species, based on the successful propagation and marketing of the rare Australian conifer, the Wollemi Pine (Heady 2012)

Approach

In the first year of this two year research project we investigated the viability and germination of 22 herbaceous or shrub species native to Victoria (see Table 1) that we believe to have horticultural merit, based on their form, foliage and/or flowers. To establish a basis for comparison with a known horticultural selection, commercially obtained seed of *Ptilotus* 'Joey', was also tested.

All species were listed as endangered, threatened or vulnerable flora in Victoria (Department of Environment and Primary Industries Advisory List of Rare or Threatened Plants in Victoria – 2014). This list covers species classified under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*), the Victorian *Flora and Fauna Guarantee Act 1988* (*FFG Act*) and from the Department of Environment and Primary Industries' own advice. All species selected were listed under at least two of these Acts.

Seed was obtained from the Victorian Conservation Seedbank (VCS). We used conventional seed testing to investigate the quality and viability of seed. Wherever possible, the most recent collection of seed was selected. Commercial seed of *Ptilotus* 'Joey' was obtained in a sealed packet from Ball Australia, Skye, Victoria. Cut tests were not replicated, and for some species, were performed on only five seeds, given the scarcity of seed. Plate tests for germination were performed in Petri dishes containing 1% agar. For species where dormancies or low germination were expected, agar plates with 250 mg/L gibberellic acid (GA_3) were used. For species where seed was readily available, 20 or 25 seeds were tested. Ten seeds were plated for species where seed was limited. Plates were incubated in a humidified germination cabinet on a 12 hour light:12 hour dark photoperiod at 20°C and 15°C respectively. Nursery sowings (one seed per cell) were made in March 2018 into 100-cell plastic trays containing a pine bark-based sowing mix with low-level controlled release fertiliser. Two trays were sown for each species, apart from *Craspedia canens* in which only one tray was sown due to low seed numbers. Trays were placed in a glasshouse maintained at 18°C under natural light (Fig 1A). Counts of seedling emergence were made weekly for up to 10 weeks.

Results

The combined outcomes of cut and plate germination tests identified three distinct patterns:
1. High % seed fill plus high % germination; 2. High % seed fill and low % germination; 3. Low % seed fill and low % germination.

Craspedia canens, *Stylidium armeria* subsp. *pilosifolium*, *Podolepis laciniata*, *Glycine latrobeana*, *Leucochrysum albicans* susp. *tricolor*, *Swainsona pyrophila*, *Xerochrysum palustre*, *Argyrotegium nitidulum*, and the reference commercial crop, *Ptilotus* 'Joey' showed high seed fill (80-100%) and high percentage germination (60-100%). Exposure to GA_3 increased germination of *Ballantinia antipoda*, *Leptorhynchos orientalis* and

Table 1. Species selected for the Raising Rarity project, with family affiliation and common name.

Family	Species	Common name
Amaranthaceae	*Ptilotus* 'Joey' – commercial reference crop	Mulla Mulla 'Joey'
Apiaceae	*Aciphylla glacialis*	Mountain Celery
Asteraceae	*Argyrotegium nitidulum*	Shining Cudweed
	Brachyscome chrysoglossa	Yellow-tongue Daisy
	Brachyscome foliosa	Mountain Daisy
	Brachyscome nivalis	Snow Daisy
	Brachyscome ridigula	Leafy Daisy
	Brachyscome tadgellii	Creeping Daisy
	Craspedia canens	Grey Billy-buttons
	Leptorhynchos orientalis	Lanky Buttons
	Leucochrysum albicans subsp. *tricolor*	Hoary Sunray
	Podolepis laciniata (syn. *Podolepis* aff. *robusta*)	High-plain Podolepis
	Podolepis muelleri	Small Copper-wire Daisy
	Rutidosis leptorhynchoides	Button Wrinklewort
	Xerochrysum palustre	Swamp Everlasting
Brassicaceae	*Ballantinia antipoda*	Southern Shepherd's Purse
	Drabastrum alpestre	Mountain Cress
Campanulaceae	*Wahlenbergia densiflora*	Fairy Bluebell
	Lobelia gelida	Snow Pratia
Fabaceae	*Glycine latrobeana*	Clover Glycine
	Swainsona greyana	Hairy Darling-pea
	Swainsona pyrophila	Yellow Swainson-pea
Stylidiaceae	*Stylidium armeria* subsp. *pilosifolium*	Hairy-leaved Trigger-plant

Rutidosis leptorhynchoides (60% higher than control values for each). In most cases, the "high fill, high plate germination" outcomes were matched by high seedling establishment in nursery cell trays. Seedling establishment ranged from 45-93% for *Craspedia canens*, *Rutidosis leptorhynchoides*, *Xerochrysum palustre*, *Argyrotegium nitidulum*, *Ballantinia antipoda* and *Leucochrysum albicans* subsp. *tricolor*. However, *Stylidium armeria* subsp. *pilosifolium*, *Podolepis laciniata* (Fig. 1B), *Glycine latrobeana*, *Swainsona pyrophila* and *Leptorhynchos orientalis* showed lower percentage nursery establishment ranging from 0.5-39% (*Leptorhynchos orientalis* and *Podolepis laciniata*, respectively).

Species with high seed fill (60-90%) but low outcomes on plate germination tests (4-32%) were *Drabastrum alpestre*, *Lobelia gelida*, *Podolepis muelleri*, *Aciphylla glacialis*, *Brachyscome chrysoglossa*, *Brachyscome nivalis* and *Wahlenbergia densiflora*. Seedling emergence from nursery sowings of these species ranged from 0 (*Aciphylla glacialis* and *Brachyscome nivalis*) to 31% (*Wahlenbergia densiflora*), with intermediate outcomes for the other four species in this group.

Swainsona greyana and *Brachyscome foliosa* showed poor seed fill and poor plate germination. Seed fill for *Swainsona greyana* (1%) was so low (due to insect larval predation) that work on this species was abandoned. While cut tests and plate germination outcomes for *B. foliosa* were similar (30% fill and 20% germination), we observed no emergence of seedlings of this species in nursery sowings.

There were two species for which we obtained only cut test or plate germination data (*Brachyscome ridigula*, 71% fill and *Brachyscome tadgellii* 40% plate germination, respectively). In these cases, cut and plate tests showed no correlation with nursery sowing outcomes, with no nursery seedling emergence of *B. ridigula*, and 54% for *B. tadgellii*.

The reference crop *Ptilotus* 'Joey' showed 100% seed fill, and all seed germinated in plate germination tests. This was higher than the germination rate provided by the supplier (66%). However, only 45% of cells in the nursery sowings produced seedlings.

Discussion and future directions

In the first year of this two-year project, we applied conventional seed testing and nursery production techniques to rare and threatened wildflower species from a range of environments in south-eastern Australia. We observed and recorded various responses, which can be related to the species' wild origins and to the quality of the seed lots. High levels of seed fill and plate germination did not necessarily translate into high levels of seedling establishment in the nursery. Further work will be undertaken to improve the reliability of nursery propagation in these species. Unsurprisingly, poor seed fill and low plate germination invariably led to poor seedling establishment in the nursery sowings.

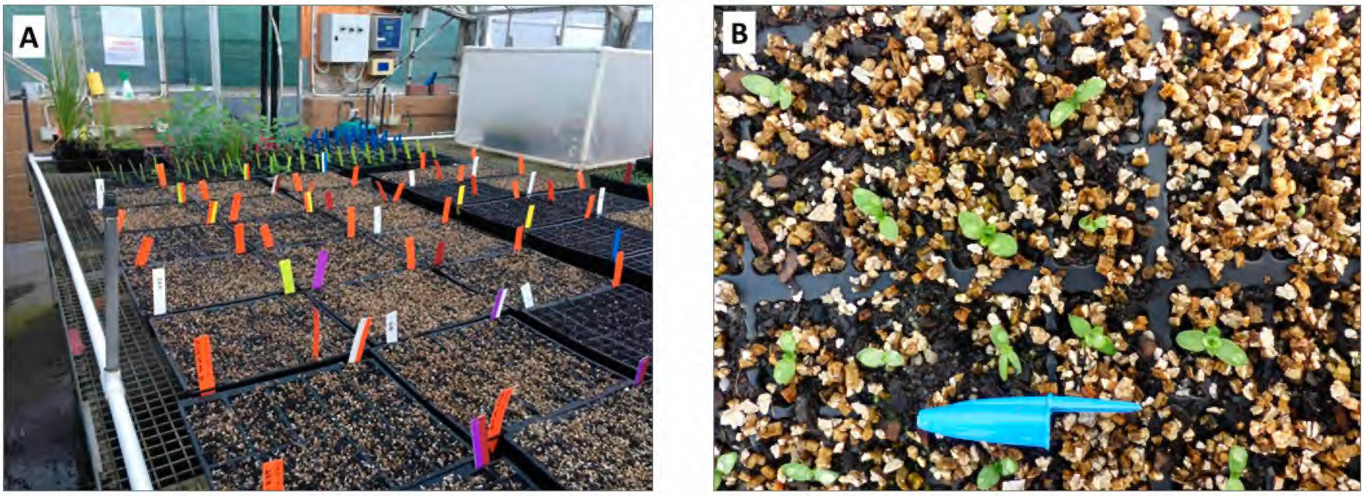

Figure 1A. A Burnley campus glasshouse which is maintained at 18°C under natural light.
B. *Podolepis laciniata* showed a lower percentage in nursery establishment. Photos: Susan Murphy.

Further work is needed to determine if poor seed fill is an inherent characteristic of these species, or simply of the seed lot. Where plate germination was unexpectedly low, the viability of the seed lot and possible dormancy or germination environment issues need to be addressed.

For this project, we recognised two broad potential horticultural markets that may adopt these rare and threatened species. The first market supplies conservationists and plant collectors, who will seek plants that retain much of the diversity of the wild populations. This inherent diversity is a challenge for conventional nursery production, which favours uniformity in both product appearance and production scheduling. The second potential market is in more traditional ornamental horticulture, where the customer is likely to value rarity but will also expect high visual appeal, uniformity and product reliability. Nurseries producing for this market will favour vegetative propagation of selected forms, or seedlings raised quickly and easily from uniform seed lines.

Both these broad markets could have a role in conserving some or all of these species, either by protecting and restoring populations that retain the wild character of the species, or by valuing the conservation of remnant populations and genetic diversity as sources for selection for ornamental horticulture.

In the second year of this project, we will grow and assess the species in containers and in-ground horticultural plantings. Those species that lend themselves to vegetative propagation will be assessed for 'superior' forms that may suit ornamental horticulture.

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Monitoring restoration success at Ken Hurst Park

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For many years, the Friends of Ken Hurst Park have been monitoring the survival of plantings and the recruitment and survival of native species in their restoration sites. Prior to 2014, survival ranged from 0 to 50%. The major trend is that the number of species and overall numbers surviving drops with each year from the time of planting. This article discusses the results of planting from 2014 to 2016 and makes comparisons to earlier results.

Ken Hurst Park is a Bush Forever site in Leeming in the City of Melville made up of banksia woodland and seasonal vegetated wetlands. With the majority of the park in excellent to very good vegetation condition, our revegetation sites are mostly closing unused tracks or in small disturbed clearings surrounded by intact bushland.

Planting techniques

Prior to 2014, we planted using standard techniques of digging holes with trowels and using tree guards to protect seedlings from strong winds and kangaroos, to provide warmth in winter and to encourage condensation of moisture in the early morning. From 2014, we trialed more disruptive planting techniques incorporating deep soil disturbance using augers and long thin shovels to see if this increased survival rates by reducing soil compaction to aid water and root penetration.

The provision of water is crucial to the survival of plants in these Bassendean sands and one of the biggest headaches to the success of revegetation in Ken Hurst Park. We watered at planting, using either a 1000L water tanker with pump and hose, or carrying water in 10-20L jerry cans. Carrying water in jerry cans by hand is a nightmare, but even the water tanker was not sufficient to adequately water all the tubestock. In addition, we employed a contractor to water planted tubestock once a month after planting, using a water tanker with a pump and a long hose to deliver 3L of water (containing a soil wetter and bioprime botanical extracts) per plant in a very time-consuming operation. In 2014 and 2015, watering was undertaken between November and March. In 2016, watering was planned to occur from May to September to provide adequate water to plants during their establishment and better prepare for the hot dry summer. However, 2016 was a wetter winter than it had been for several years, so watering was only undertaken between significant rain events.

Further watering was not undertaken in 2017/2018. Plant guards were also not removed from any of the plants until more than a year after planting because there was evidence of substantial browsing by kangaroos. This was not totally successful, as kangaroos continued to push the plastic bag towards the ground in the process of lowering their heads.

Monitoring methods

We planted close to 2800 plants in 2014–2016. We kept a record of the numbers of each species planted in the different revegetation areas. Each year in summer or autumn, all surviving plants in the different revegetation areas were counted and tallied by species for each area. Some areas have been monitored at different times depending on the availability of volunteers.

We also recorded natural regeneration each year by counting the number of plants of each species germinating from seed in, or falling on, the soil in the revegetation areas, though individual plants were not tracked.

With the majority of Ken Hurst Park in excellent to very good vegetation condition, our revegetation sites are mostly closing unused tracks or in small disturbed clearings surrounded by intact bushland. This is Area 14, photographed in March 2018, having experienced three summers after planting in July 2015. We are yet to achieve an average of more than 50 percent tubestock survival rates. Photo: Eddy Wajon.

Plant survival

Figure 1 shows the number of plants in each area counted at each monitoring session between 2014 and 2018. The most recent monitoring took place in March-April 2018. The trend of diminishing survival over time is evident in all areas with the survival of all species and overall numbers surviving dropping each year since planting in 2014–2016.

Survival of tubestock planted in one section of the northern banksia woodland (areas 4, 12/13) averaged 33% (range 31–33%). The average survival of tubestock planted in a different area (areas 14, 15) was 54% (range 53-57%). The tubestock planted in the southern banksia/ paperbark dampland (areas 16A–C) had an average survival of 40% with a range 34-51%. The slight survival difference between the different planting techniques in this area (digging small holes with trowels or using Potti Putkis; disturbing the ground first with specially designed long thin shovels; and pre-augering the soil) was not statistically significant (p= 0.3).

The range of overall survival in different areas was 30-58% with the median 35% and an average of 44%. This should be compared with tubestock planting in other areas of Ken Hurst Park in 2011-2013 where survival in April 2018 in the northern banksia woodland ranged from 21 to 41% with a mean of 31%. Survival of tubestock planted in 2011-2013 in the southern banksia/paperbark dampland area averaged 12% in March 2016.

Of course, the average survival of tubestock hides differences between different species. Forty eight banksia woodland species were planted. The majority of the 2800 tubestock were from a wide range of understory shrubs, a third were dominant canopy trees, and a small proportion was herbs. In Table 1, species are listed in order of greatest survival ranging from *Patersonia occidentalis* and *Regelia ciliata* with about 100% survival to *Rhagodia baccata* with 0% survival.

Table 1. Percentage survival by species averaged across all areas (in order of per cent survival)

>75%	*Patersonia occidentalis, Regelia ciliata, Melaleuca thymoides, Jacksonia furcellata*
50–75%	*Eucalyptus todtiana, Xanthorrhoea preissii, Acanthocarpus preissii, Allocasuarina humilis, Bossiaea eriocarpa, Verticordia densiflora, Banksia ilicifolia, Dasypogon bromeliifolius, Scholtzia involucrata, Daviesia physodes, Eremaea pauciflora, Dampiera linearis, Hibbertia hypericoides, Melaleuca preissiana*
25-49%	*Calytrix fraseri, Hypocalymma robustum, Banksia menziesii, Melaleuca seriata, Dryandra lindleyana, Macrozamia fraseri, Banksia attenuata, Gastrolobium capitatum, Acacia pulchella, Lechenaultia floribunda, Conostylis aculeata, Stirlingia latifolia, Eucalyptus marginata*
10-25%	*Allocasuarina fraseriana, Cyathochaeta avenacea, Phlebocarya ciliata, Daviesia nudiflora, Hovea trisperma, Dianella revoluta, Hardenbergia comptoniana, Melaleuca lateritia, Kennedia prostrata, Acacia huegelii, Daviesia triflora, Hovea pungens*
<10%	*Beaufortia elegans, Gompholobium scabrum, Calytrix flavescens, Nuytsia floribunda, Rhagodia baccata*

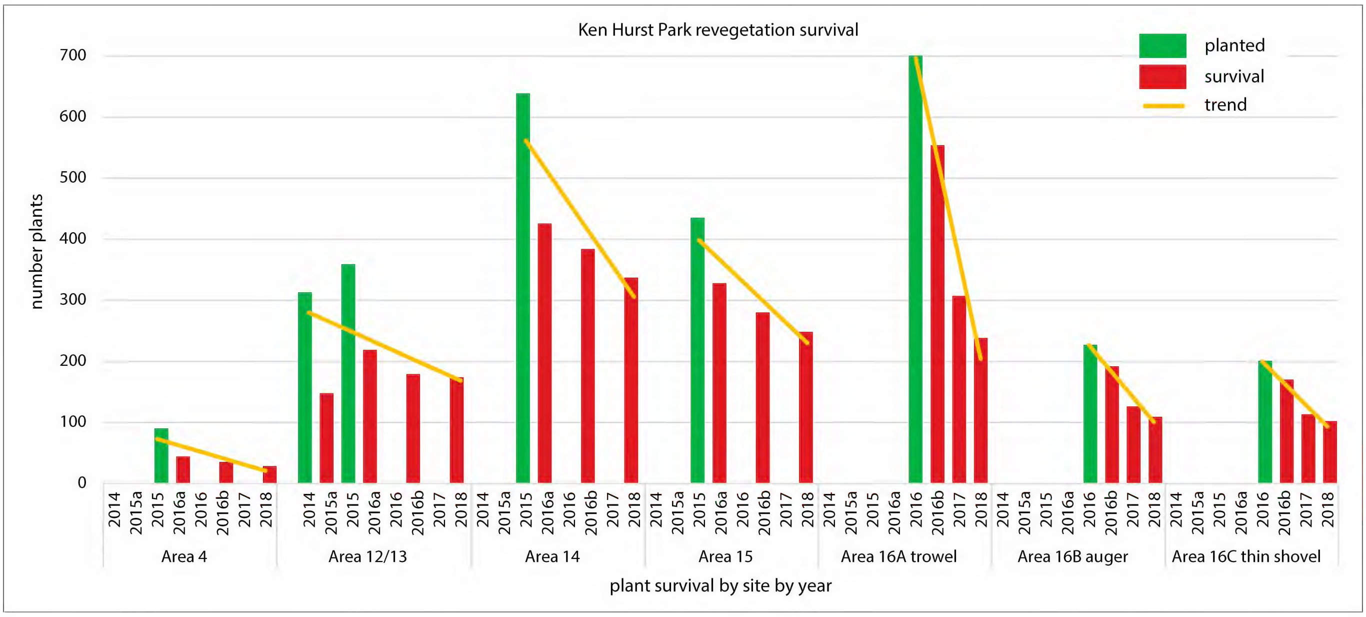

Figure 1. Plant survival in absolute numbers at Ken Hurst Park revegetation areas planted in 2014–16. Green columns show the numbers of tubestock planted and red columns show the surviving plants at each monitoring date, the trend line is in yellow. The sites were monitored at different time frames due to volunteer availability. Dates followed by 'a' were monitored before winter and dates followed by 'b' were monitored after winter in that year. Areas 4–15 were situated in the northern banksia woodland and Areas 16A–C in the southern banksia/paperbark woodland. Note that Area 12/13, which was planted over two years, records both surviving plants plus new tubestock in the column for the second planting in 2015.

A very pleasing feature of the restoration activities was the appearance of a wide range of self-germinating plants. Over the four years of monitoring, a total of 4250 plants from 56 species were recorded naturally regenerating from seed or suckers. Whether any of these were individuals seen on more than one occasion was not recorded. About half of these species were those in our planting list, with the other half not being in our planting list. The most common self-germinating plants were *Podotheca gnaphalioides* (an annual), *Dampiera linearis* (a sucker), *Hibbertia subvaginata* (a short-lived plant), *Gompholobium tomentosum* (a legume) and *Banksia attenuata*.

The combined data on self-germinating plants from summer 2016 and autumn 2018 are shown in Figure 2. This shows the variation in natural regeneration experienced between the sites, though this is greatly influenced by size of the different areas. It should also be noted that there was a peak in self-germinating plants seen in summer, as this included annuals that were not seen in autumn.

Survival of these self-germinating plants was also variable, with some deaths. However, there was high germination and survival of *Banksia attenuata* from soil-stored seed along a couple of the tracks on the north side of the railway line, and many plants are now well established. The total numbers of germinating perennial plants is less than the number of surviving tubestock, but they contribute significantly to the vegetative cover.

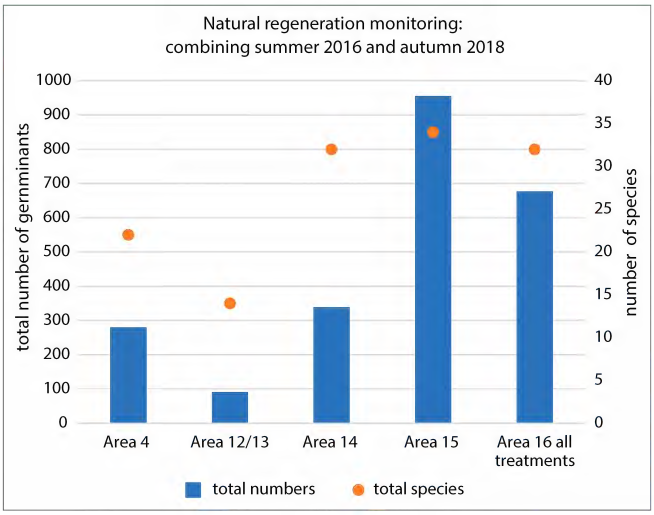

Figure 2. Number of individuals and number of species of self-germinating plants in different planting areas. Total numbers counted in blue columns and total number of species as orange markers.

Conclusions and comments

We have yet to achieve average tubestock survival rates greater than 50%. Earlier planting (May versus July), watering in winter, a (relatively) wet winter in 2016 and substantial rain in summer 2017 did not appear to have substantially increased tubestock survival in the northern dryland banksia woodland over what we have achieved in previous planting campaigns.

The Friends of Ken Hurst planting tubestock at Area 14 in July 2015. Photo: Jane Hilton.

Author Eddy Wajon with a surviving planted *Banksia menziesii* flowering for the first time. Photo: Donna Wajon.

However, tubestock survival in the southern dampland banksia woodland did appear to have been considerably better (40% from planting in 2016 compared to 12% from planting in 2011-13), though the method of planting did not seem to be responsible.

Some planted species seem to survive better than others though this did depend on whether it was a dryland or dampland environment. For example, banksia survival was poor (20-30%) in the dampland environment, and good in the dryland environment (25-70%).

Overall, the survival of tubestock from our planting in 2014–16 was disappointing and lower than hoped for given watering, including in winter, relatively wet winters and summers, and the more disruptive planting methods used. The continuing relatively low tubestock survival could potentially be due to the following factors:

- Inadequate watering and soil moisture, particularly over summer.
- Soil water repellency, especially in the dampland area.
- Leaving plastic plant guards in place during the heat of summer.
- Residual soil compaction.
- Herbivory by kangaroos and rabbits.

The following strategies may need to be employed to improve tubestock survival in Ken Hurst Park:

- Watering once a week for the first 12 months. This would be very labour intensive if done by hand and using volunteers, or very expensive using contactors, even when using a 1000L tanker. Alternatively, an irrigation system with a network of pipes, a tank and a pump could be installed. However, this is expensive, prone to theft and very labour intensive to install.
- Removing plastic plant guards by September despite the high predation and damage caused by kangaroos.
- Using wire mesh plant guards. However, these do not provide warmth or water harvesting services in winter, are harder to install and not as easy to recycle/repack.
- Using core flute plant guards. However, these are very expensive and do not necessarily avoid the issue of overheating inside the plant guard.
- Placing mulch/leaf litter around the tubestock. The problems with this are sourcing suitable, locally native and sterile material, either commercially or from site.

The alternative may be to source and plant large numbers of tubestock, using potti putkis, dispense with plants guards and allow nature to take its course. This would be much less labour intensive and expensive than the current strategies, and the absolute number of survivors may be the same. The real serious concern is that similar strategies have been used in the past with very poor success due in large part to kangaroo herbivory. A mid-course may be to use wire mesh plant guards as well to reduce kangaroo herbivory.

Closing a track in Area 16, the southern dampland. This area currently and historically has experienced lower survival rates compared to the northern dryland Banksia woodland at Ken Hurst Park. Photo: Eddy Wajon

Fire is the key to survival of Avenue Cassinia

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Background

Avenue Cassinia (*Cassinia tegulata*) is a nationally threatened species occurring in south-eastern Australia. The species has a limited range, in the South East region of South Australia to western Victoria. With a preference for interdunal wetland habitats, Avenue Cassinia has undergone significant reductions in both area of occupancy and population size as a direct result of extensive drainage and land clearance (Thompson and Haywood 2017). Other major threats to the species' long-term survival include climate change, population isolation (limiting recruitment and decreasing genetic diversity), herbivore pressure, environmental weeds, loss of Indigenous use of fire as a land management tool and overall lack of species knowledge.

Currently, Avenue Cassinia occurs mainly along roadsides with all populations in South Australia except one experiencing rapid decline and with no recruitment observed; two populations have become extinct since 2009 (Dickson 2016). A new population was created on private land by planting purpose-grown seedlings in 2010-2011. This *ex situ* population, of over 60 plants, remained in good condition to 2017; however, recruitment was also not observed at this site. While planting tubestock is one method to increase the total population of a species, the benefits of fire were also considered.

In 2017, Nature Glenelg Trust (NGT), finalised a Translocation Plan for Avenue Cassinia that outlined the steps which would be taken to bolster the number of extant populations by growing and planting tubestock. In May of that year, NGT undertook a small ecological burn at the *ex situ* private land population as part of the broader translocation program.

This work formed part of the Restoring Under-represented Ecological Communities project, which was supported by Natural Resources South East (DEW) and the Australian Government.

Species information

Avenue Cassinia is listed as Critically Endangered under the Commonwealth legislation, Endangered in South Australia and Threatened in Victoria. The species appears closely associated with seasonally inundated flats of *Melaleuca brevifolia*/*Gahnia filum* Shrubland and has a distribution in the upper South East of SA and western Victoria (near Edenhope) (Thompson and Haywood 2017).

Avenue Cassinia is a small to medium-sized shrub from the daisy (*Asteraceae*) family. It has an upright habit, grey-green to yellowish green, hairy, needle-like leaves, fissured brown bark and off-white to cream flowers at the end of branches (Figure 1). Flowers are honey-scented, but leaves and stems are odourless and not sticky (DEH 2006).

It is thought that the lack of recruitment and decline of certain populations may be a result of lack of appropriate disturbance. While germination trials by the South Australia Seed Conservation Centre provided variable results, anecdotal evidence suggests that Avenue Cassinia may be disturbance and/or fire responsive (Thompson and Haywood 2017). Little information on fire response, age to flowering and recruitment post-fire is available. A Translocation Plan was prepared for this species to address population declines through planting of tubestock and to trial mosaic burning (Thompson and Haywood 2017).

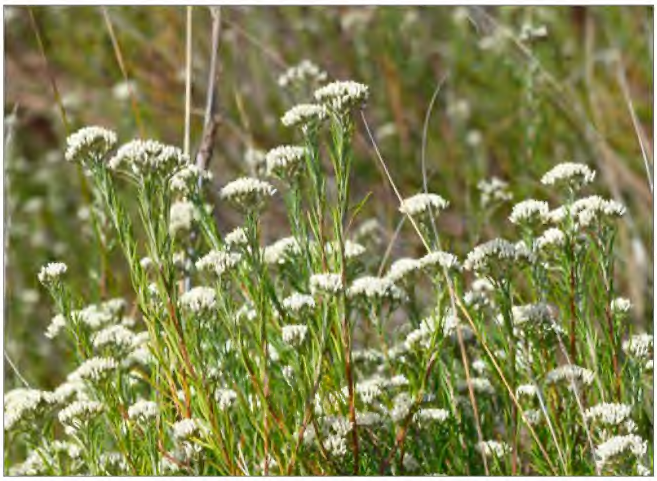

Figure 1. ***Cassinia tegulata*** **in flower at Avenue (SA). Photo: Bryan Haywood**

Ecological burn site and method

The ecological burn took place on a private property called Bull Island west of Avenue, SA, where a new Avenue Cassinia population was created in 2010-2011. The initial works included fencing and planting 80 Avenue Cassinia seedlings, through the State Herbarium of South Australia's Millennium Seed Bank partnership with Kew Gardens, UK.

The total fenced area is 2,200 m^2 and the burn took place over 550 m^2. At the time of the burn vegetation on site was dominated by dense sedges and grasses including *Lepidosperma* sp., *Phalaris* sp., *Holcus* sp. and *Gahnia* sp. with a small number of mature Avenue Cassinia plants at the edge (Figure 2). This specific area was selected for the burn to facilitate germination of wind-blown seed and to simplify post-fire weed control amongst otherwise dense shoulder-height vegetation.

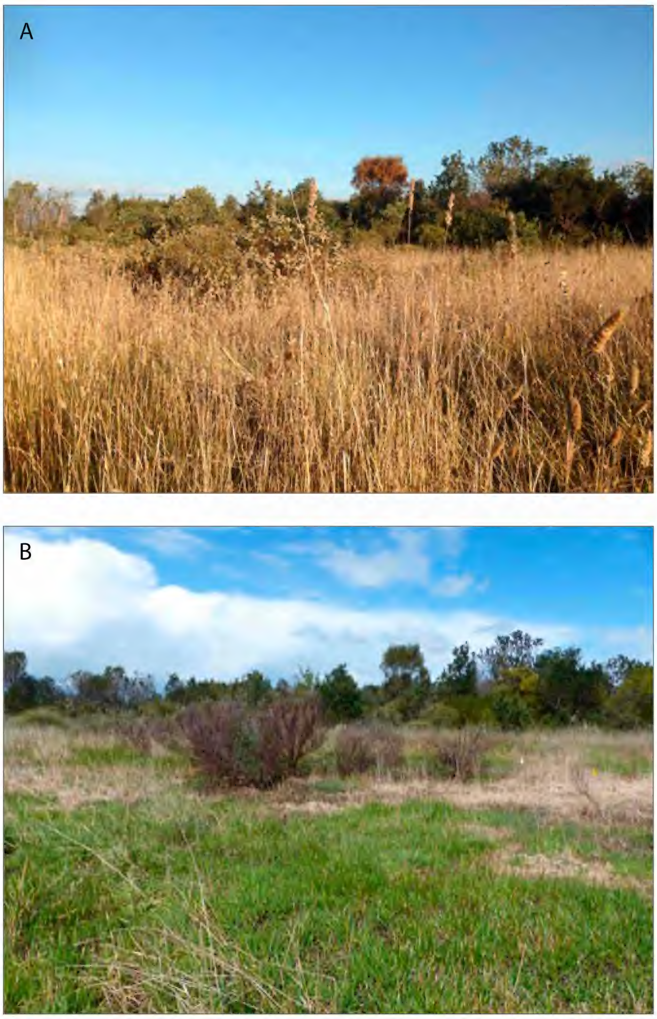

Figure 2. A. Pre-burn 15 May 2017. B. Post-burn 13 September 2017. Photos: Bryan Haywood

The burn was conducted on 15 May 2017 at 15:45 hours with a slight breeze from the south-east, during clear and cool weather conditions (Figure 3). The burn area did not have an existing fire break, so a reduced fuel zone was created by burning the north-western side first, taking into consideration wind direction. Strips were then lit across the treatment area, in a south-west to north-east direction, moving from west to east until the entire area was burnt. The burn area deliberately incorporated five mature *Cassinia tegulata* shrubs to investigate the species' fire response. The burn was completed and all flames extinguished within 65 minutes.

Results

The burn successfully opened up the dense grass/sedge habitat and allowed new seedlings and clusters of regeneration to be marked. The five mature plants were all scorched, with four of the five dead post-fire. More than 100 germinants (<4 cm) were observed four months post-fire. The following autumn, less than 12 months post-fire, flowering was observed in three new plants ranging from 10-40 cm in height (Figure 4). The bulk of new plants at this time were <40 cm and not flowering.

On 14 September 2018 the population count at this site had increased to 239 plants; 205 individuals were <50 cm and 34 individuals were >50 cm. Eight individuals were flowering at the time of survey; two were <50 cm and six were >50 cm.

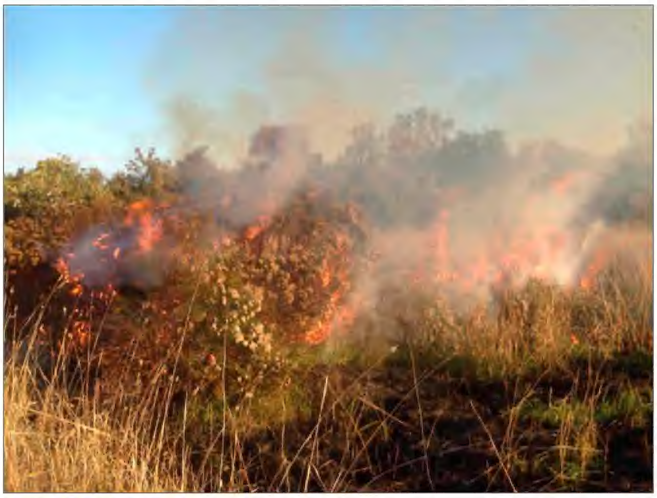

Figure 3. Avenue Cassinia on fire at Bull Island, Avenue (SA). Photo: Bryan Haywood

Follow-up site management

The introduced grasses on site responded vigorously, as expected, to the fire in the following 6-12 months, and were controlled by spraying a grass selective herbicide. The cut and swab herbicide application was also used on the few Dog Rose (*Rosa rubiginosa*) present that were not affected by the burn.

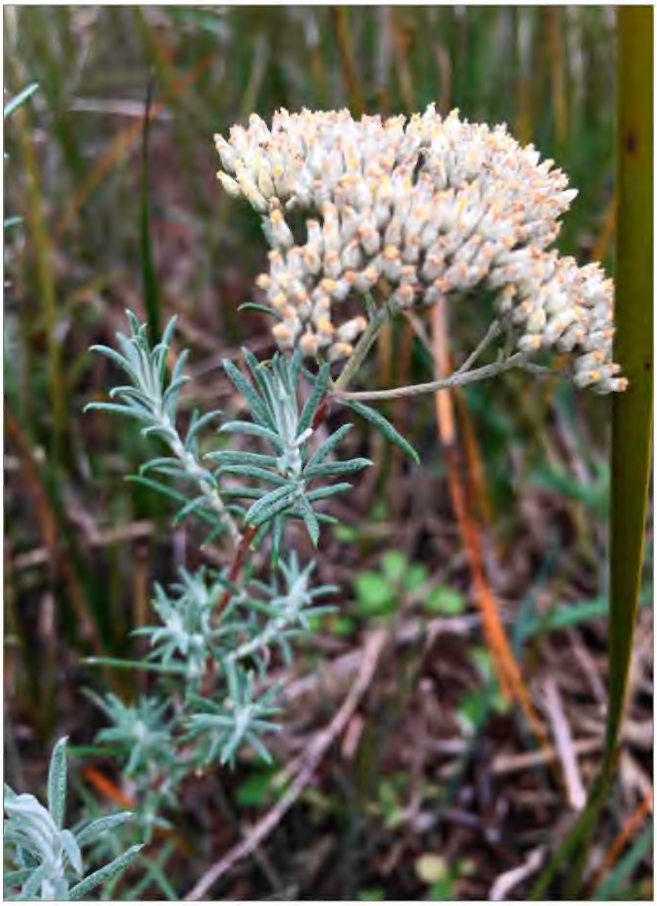

Figure 4. Seedling *C. tegulata* in flower. Photo: Sam Rothe

Conclusion and recommendations

The season and intensity of the burn resulted in encouraging germination of Avenue Cassinia. Post-fire grass control was essential to the survivorship of the new recruits. The burn was completed with minimal resourcing – one 800 L fire unit and two fire crew personnel. Nature Glenelg Trust is in the planning stages to implement a larger burn at a roadside crown land population in the near future, with assistance from Department for Environment and Water (SA).

Acknowledgments

Nature Glenelg Trust wishes to thank Kerry Gilkes for allowing this project to go ahead at Bull Island and for her assistance with the burn. Nature Glenelg Trust staff are thanked for their involvement in the planting, burn monitoring and post-fire weed control. This project was supported by South East Natural Resources Management Board, through funding from the Australian Government's National Landcare Programme.

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Population reinforcement: Learning from *Allocasuarina robusta*

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Allocasuarina robusta

Allocasuarina robusta is protected under Commonwealth (*Environment Protection and Biodiversity Conservation Act 1999*) and State legislation (*National Parks and Wildlife Act 1972*). The species is listed as Endangered because of its restricted distribution and a variety of threatening processes (Quarmby 2011). The threatening processes are largely historical practices including land clearing, swamp drainage and grazing, some of which are continuing today (Quarmby 2011).

Allocasurarina robusta is restricted to wetland peripheries on the Fleurieu Peninsula, in the Southern Mount Lofty Ranges in the Kanmantoo bioregion of South Australia (Department for Environment and Heritage 2007). The total distribution of *Allocasuarina robusta* is confined to an area of 172 km^2 (Quarmby 2011). The species has several smaller fragmented subpopulations in localities including Yundi, Mount Compass, and Hindmarsh Tiers (Figure 1); there may be more subpopulations on private land which have not yet been documented (Quarmby 2011). Historically, *Allocasuarina robusta* is thought to have had a much larger distribution on the Fleurieu Peninsula, and extended further northwards into the Central Mount Lofty Ranges (Quarmby 2011). Since settlement, there has been extensive vegetation clearance in the Southern Mount Lofty Ranges, such that remnant vegetation has been reduced to 9% (Bickford and Mackey 2004). The Fleurieu Peninsula wetlands are listed as a critically endangered community under Commonwealth and State Government legislation (Department for Environment and Heritage 2007).

Species with limited distributions and small populations are vulnerable to the impacts of random catastrophic events. Additionally, small populations can be threatened by genetic drift or inbreeding depression (Finlay *et al.* 2017). Genetic drift can be exacerbated in small, fragmented populations, where there is no genetic exchange, such that entire populations may be closely related (Finlay *et al.* 2017). The outcome of an inbreeding depression can lag behind fragmentation as it may take more than a generation to appear (Broadhurst 2011). The effect of fragmentation on a species' genetics can be difficult to predict, and can be positive or negative (Raabová *et al.* 2007, Broadhurst 2011). Restoring genetic diversity in populations which have reached critically low numbers can occur through using translocated plants (Raabová *et al.* 2007). However, introducing material from other populations can have impacts on populations which may not be immediate nor beneficial towards the population (Broadhurst 2011).

Allocasuarina robusta genetics and translocation

An understanding the spatial genetics of *Allocasurarina robusta* is important as it can provide direction for revegetation with/translocation of *Allocasurarina robusta,* and provide insight into the impact of past translocations (Quarmby 2011).

Genetic analysis can be used to increase our understanding of both population dynamics and taxonomic status (Chrungoo *et al.* 2018), as well as giving insights into the species' evolution and the potential for future genetic drift. Genetic analysis can also be used to inform translocation/revegetation programs. Genetically diverse populations can be used as part of a translocation program to aid populations lacking in genetically diversity (Chrungoo *et al.* 2018). Using genetically diverse populations to supplement populations with low genetic diversity can reduce the threat posed by genetic drift (Chrungoo *et al.* 2018). However, populations which have low genetic diversity should not be assumed to be threatened, as they may be adapted to the specific environment in which they are found (Raabová *et al.*2007).

Raabová *et al.* (2007) argue that increasing distance between selected (tube stock) population and the reinforced population will result in increases in failure rate. This has implications for seed collection for revegetation. Raabová *et al.* (2007) were not alone in identifying this issue, Breed *et al.* (2012) considered locally collected seed was vital for a project success. Breed *et al.* (2012) reported that land managers are increasingly aware of ensuring seed of local provenance is used. The use of local-provenance seed can reduce the impact of maladaptation and/or outbreeding depression (Breed *et al.* 2012). Collecting seed locally may mean the integrity of the species is maintained, but this can come at a cost of possibility creating an population with poor genetic health. Nevertheless, there are examples of successful establishment of populations of species with extremely restricted populations *i.e.* Whibley Wattle (*Acacia whibleyana*) (Jusaitis and Sorensen 2007).

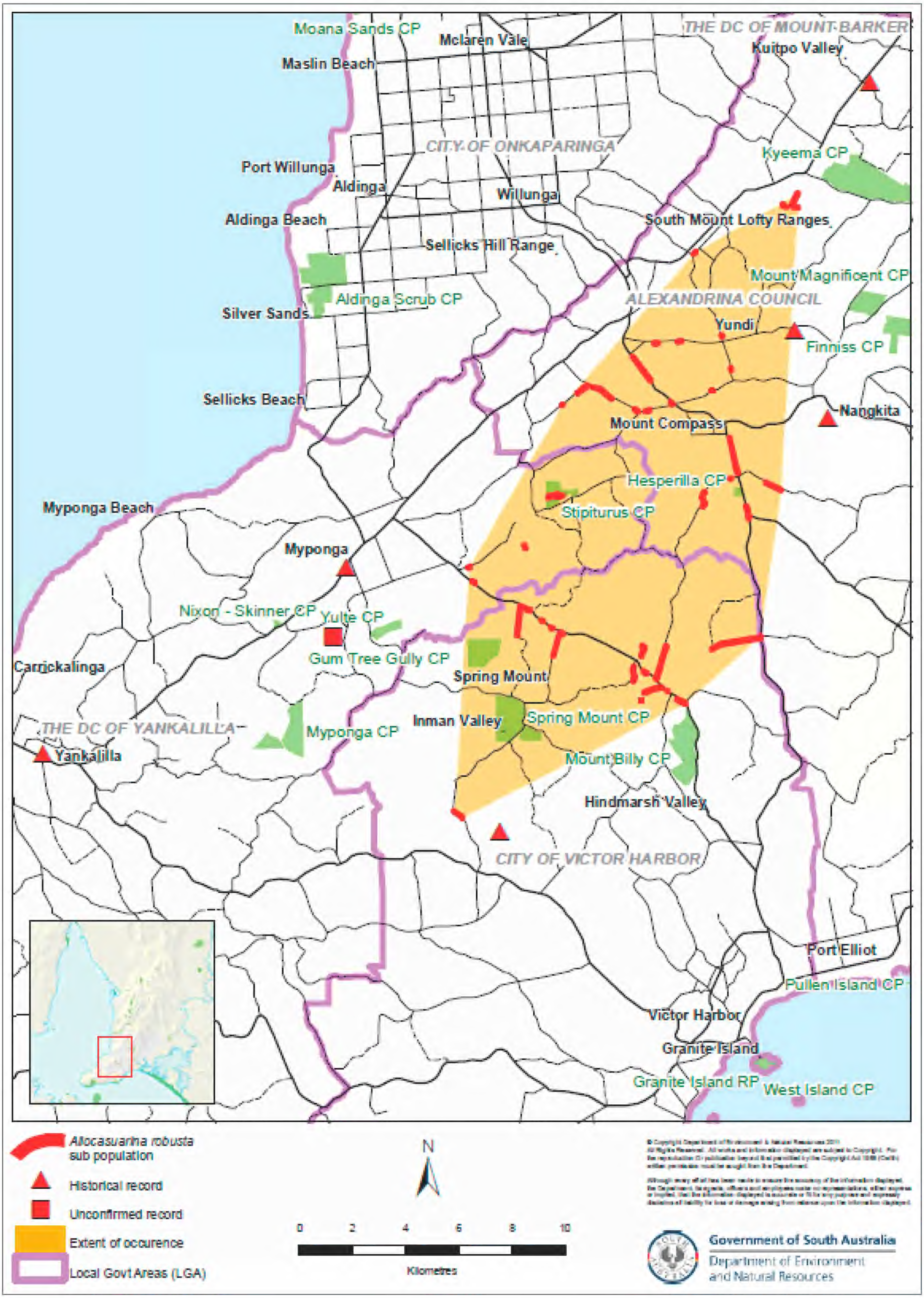

Figure 1. Distribution Map of *Allocasuarina robusta* (reproduced from Quarmby (2011))

The success of these revegetation projects may reflect consideration of the seed source, in relation to the site where it is to be used.

Allocasurarina robusta recruitment and translocation

Allocasuarina robusta appears to have little-no natural recruitment occurring from seed, and little is known about its seed ecology. Recruitment from seed is important as it affects a species ability to disperse and recolonise, and it can be important for species persistence (Arruda *et al.* 2018). However, germination of seed can be a high-risk recruitment strategy, with seedlings typically the most vulnerable stage of a plant's life cycle. For example, the level of mortality of seedlings may be three times that of saplings (Metz *et al.* 2018). *Allocasaurina robusta* can resprout from lignotubers (Quarmby 2011).

Quarmby (2011) details how translocation can be used as a strategy for conservation of *Allocasurarina robusta*. Genetic analysis can be used to determine which tubestock are planted where, to maximise genetic diversity (Bower and Hipkins 2017, Browne and Karubian 2018) . Quarmby (2011) references an unpublished genetics study of *Allocasurarina robusta*. If and how genetic analysis of *Allocasuarina robusta* has been used in informing translocation is unclear. It is also unknown whether any populations of *Allocasurina robusta* have genetic problems (*e.g.,* inbreeding), and whether the addition of tubestock may remedy this, and indeed, whether an increase in genetic diversity may improve rates of recruitment from seed.

Summary

The lack of natural regeneration by *Allocasurarina robusta* is concerning, especially considering that many of the mature individuals are beginning to senesce, or are affected by habitat disturbance. Being in a fragmented landscape, understanding natural regeneration is paramount for ensuring the species survival.

The population of *Allocasuarina robusta* in the Mount Lofty Ranges is fragmented, and the genetic relationships among subpopulations are unknown. While morphological studies could be used to identify possible subpopulations, the use of genetics would be advantageous. An understanding of the genetics of the population may also provide insight into the species' limited recruitment. Moreover, further study of *Allocasurarina robusta* may offer an opportunity to understand the impacts of translocation on natural populations. Particularly important is an understanding of genetics of the populations of *Allocasurarina robusta* from which revegetation/translocation material is sourced, and where it is planted.

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A Forest Biosecurity program

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The importance of Australia's Forests

Australia's forests represent the seventh largest forest estate in the world encompassing native, planted and urban forests. The forest sector contributes $23 billion dollars annually to Australia's economy as well as providing ecosystem services that are difficult to quantify in dollar terms. Similarly, the heritage, amenity and tourism values while not quantified are undoubtedly large. Over 100 stakeholder groups have been identified, ranging from Federal, State and Local governments, to the forest wood and non-wood products sectors, the building industry, natural resource management groups and, environment and community groups.

The growing threat of exotic forest pests

Historically, Australia has been well served by its geographic isolation and robust biosecurity system. Many of the major forest pests present in other parts of the world are absent. Mass tree deaths across forest stands as a result of exotic pest incursions or due to indigenous pests are rare events. Pest management has therefore not been a significant cost burden for managers of Australian native forests. The absence of exotic forest pests has also in part contributed to the successful development of a multibillion-dollar softwood plantation industry in Australia. Similarly, many of the tree species in streets, parks and recreational areas that make up our urban forests are free of pests, resulting in low pest management costs for local and state governments. That is, the absence of significant pests underpins the biodiversity and sustainability of our forest assets enabling low forest pest management costs relative to other countries.

Over the last few decades exponential increases in tourism and international volumes of trade, failure to adequately resource biosecurity agencies and a downward trend in technical and scientific capacity have all contributed to an increased rate of establishment of exotic forest pests (Figure 1). Further contributing to the biosecurity risks, the planting of *Acacia* and *Eucalyptus* species over large areas across the world in the last 100 years has seen the emergence of novel pests that use these species as hosts. As these exotic pests are moved through global trade and travel networks they pose an existential threat to the flora of Australia and its unique ecosystems. This has been evidenced by the case of Myrtle Rust (*Austropuccinia psidii*). Originating in South America, *A. psidii* was first detected in NSW in 2010, and has spread across the entire eastern seaboard. Worldwide, over 450 Myrtaceous species are susceptible to *Austropuccinia psidii*, and it has already resulted in species extinctions. The 'strain' of *A. psidii* currently established is fortunately not having a large impact on species of *Eucalyptus*, however there are a number of strains overseas that affect *Eucalyptus*. If introduced, the cumulative effects of these strains would likely have catastrophic effects on the heritage, social, environmental and economic values of many of Australia's forests and woodlands. Can we imagine Australia without gum trees? What would this mean to survival of Koalas?

Currently there are 25 recognised high-risk exotic pests that pose a threat to Australia's native, plantation and urban forests and new pests are emerging overseas regularly.

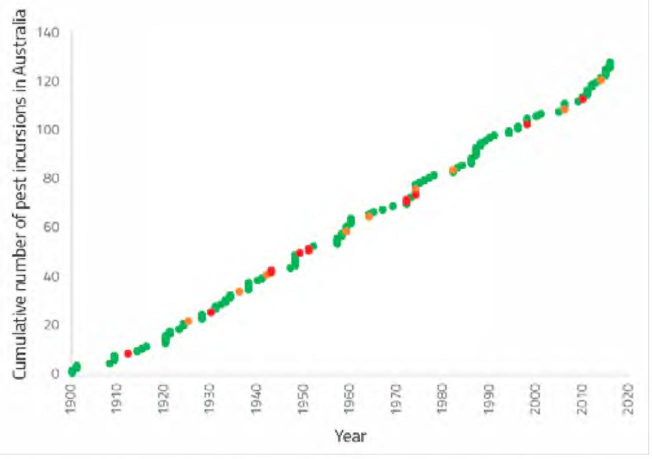

Figure 1. Exotic forest pest establishments into Australia over time. Red dots represent pests that have had or continue to have significant impacts on forest values or have incurred large pest management costs. Orange dots represent pests with a moderate impact and green dots represent pest that have had a low impact.

Impacts of forest pests

Of the exotic pest species that have already established in Australia, 15 per cent have caused large economic or environmental impacts that require significant expenditure for on-going management (Figure 1).

In native forests the most notable historical example is *Phytophthora cinnamomi*. Over 600 native plant species are susceptible and it has been responsible for changing forest ecosystem dynamics through large-scale tree deaths and reductions in biodiversity. Management costs are anecdotally known to be significant across the conservation, tourism, mining and forest sectors but are largely unquantified. Similarly, to date the costs of management for *A. psidii* have not been quantified, though it does seem set to cause equally large-scale biodiversity changes.

In softwood plantations, the establishment of the exotic pest sirex woodwasp (*Sirex noctilio*) has resulted in significant losses and ongoing management costs. Between 1987-1990, a single large outbreak of sirex woodwasp in South Australia and Victoria killed over five million trees costing $17.5 million. The National Sirex Woodwasp Control Program has cost the softwood industry an estimated $16.5 million over 65 years and currently costs the industry $0.60 per hectare per annum.

Exotic pest introductions can also result in significant pest management or tree replacement costs in urban forest settings. Conservative estimates for replacement costs of urban trees are between $5000-$12,000 per tree. No national inventory of urban trees exists, however their number is easily in the tens of millions and a conservative estimate of their replacement value is in the billions of dollars. That is, they represent a significant capital asset for Australia.

Economic impacts of exotic pests that are not commonly calculated include the costs related to the reduction of forest ecosystem services. These include increased soil erosion and localised flooding, reduced carbon sequestration and, reductions in habitat and biodiversity. Heritage, amenity and tourism values also must be taken into consideration. Many tree species have a strong spiritual and cultural value for Australia's indigenous peoples, and many communities across Australia have significant tree registers, arboreta or tree groves that have been planted to commemorate fallen ANZACS or significant community members. Trees and forests are key to the natural beauty and amenity of many of Australia's iconic landscapes and public spaces such as the Blue Mountains, Tasmania's Cradle Mountain, Adelaide's Parklands or Perth's King's Park. Australia's tourism industry contributed $54 billion to the Australian economy, while unquantified it is evident that trees and forests do contribute to the attraction of these places for both tourists and locals alike. Further research into quantifying the non-wood values of forests is essential to further prosecute the case for continued investment in their protection.

Australia's Biosecurity System

Australia's biosecurity system involves shared stakeholder responsibility and risk-reducing activities along the biosecurity continuum: pre-border, at the border and post-border (Figure 2). Roles, responsibilities and cost-sharing arrangements between governments and industry groups in responses to exotic plant pest incursions are outlined in the *Emergency Plant Pest Response Deed* (EPPRD) and *PLANTPLAN*. Where the exotic pest impacts on environmental and amenity values, rather than crop production, arrangements are set out in the *National Environmental Biosecurity Response Agreement* (NEBRA).

Biosecurity arrangements governing exotic pest preparedness and risk reduction activities are less clearly defined. Plant Health Australia has been working with stakeholders to drive improvements in this area through industry biosecurity plans (IBPs) and industry specific surveillance programs. Currently Australia lacks a coordinated post-border surveillance program that targets exotic forest pests (Figure 2).

Towards a National Forest Pests Surveillance Program

In response to the growing trend of forest pest establishments into Australia and concerns voiced by forest health experts, the Department of Agriculture and Water Resources (DAWR) funded a forest biosecurity forum in August 2015 that led to the development of the *Framework for National Biosecurity Surveillance of Exotic Forest Pests*. The Framework identified gaps in Australia's biosecurity arrangements and made recommendations for improvement. Notably, the establishment of post-border surveillance arrangements focused on forest pests.

A further workshop was held in August 2016 to discuss possible post-border forest biosecurity surveillance activities. Feedback obtained from the Framework document and the workshops recognised that forest biosecurity activities were likely to benefit multiple stakeholders and involve a mix of public and private benefits. This led to the development of a *National Forest Biosecurity Surveillance Strategy and Implementation Plan 2018-2023* (NFBSS) that considered native and urban forests biosecurity needs and included environment and community stakeholders. The NFBSS details the estimated costs for 10 major actions and 30 associated tasks for consideration by all forest stakeholders. It provides a clear vision that is aimed at establishing a *National Forest Pest Surveillance Program* (NFPSP).

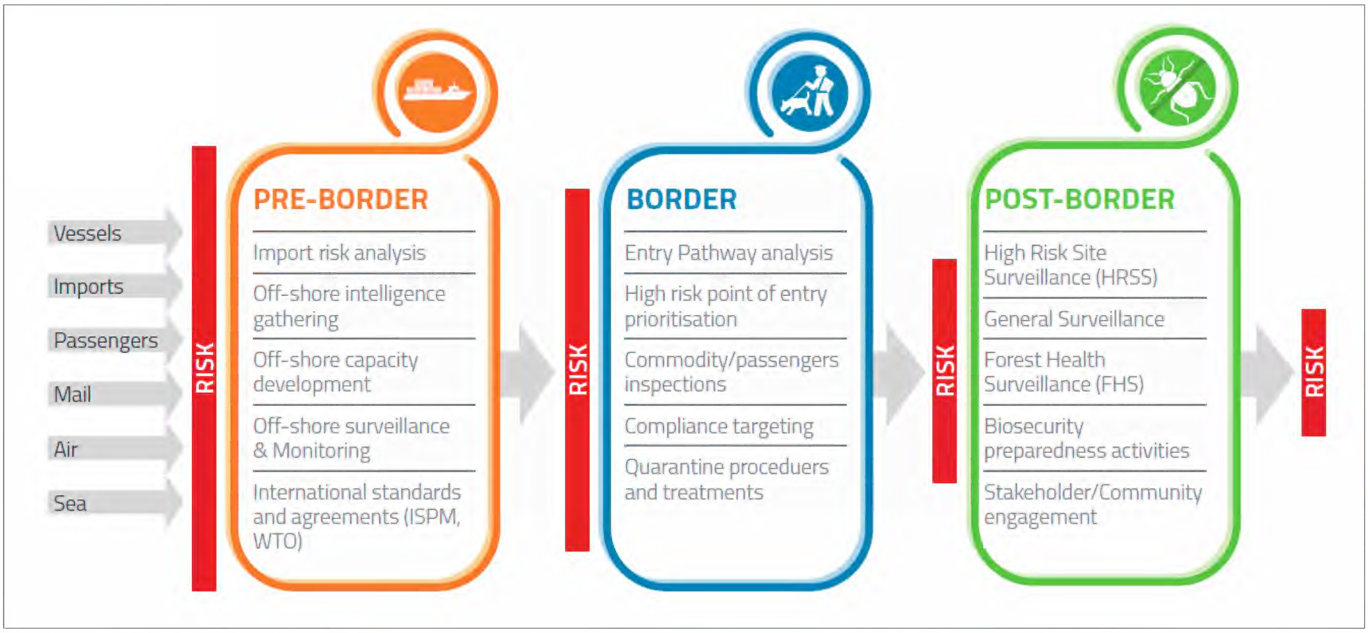
Vessels
Imports
Passengers
Mail
Air
Sea
RISK
PRE-BORDER
Import risk analysis
Off-shore intelligence gathering
Off-shore capacity development
Off-shore surveillance & Monitoring
International standards and agreements (ISPM, WTO)
RISK
BORDER
Entry Pathway analysis
High risk point of entry prioritisation
Commodity/passengers inspections
Compliance targeting
Quarantine procedures and treatments
RISK
POST-BORDER
High Risk Site Surveillance (HRSS)
General Surveillance
Forest Health Surveillance (FHS)
Biosecurity preparedness activities
Stakeholder/Community engagement
RISK

Figure 2: Risk mitigating activities that occur across a biosecurity continuum pre-border, at the border and post-border. Grey arrows represent the flow of trade and visitors into Australia. Red bars represent the diminishing risk of exotic pest entry or establishment due to the activities undertaken at each stage along the entry pathway.

Forest biosecurity an opportunity for environmental biosecurity

The proposed NFPSP outlines a coordinated approach to post-border surveillance designed to reduce the risk posed by exotic forest pests (Figure 3). The NFPSP proposes a sustainable funding partnership between Australian governments and the forest sector. Governance arrangements would include funding partners as well as community stakeholders. Main activities would include high-risk site surveillance and general tree/forest health surveillance supported by adequate diagnostics and provision of forest/tree pest training and reporting tools. To avoid conflicts of interest the NFPSP would be managed through Plant Health Australia.

Due to their worldwide distribution and large areas planted the genera *Eucalyptus* and *Acacia* provide the greatest opportunity for new exotic pests to emerge that would potentially affect Australia's environment. Supporting an NFPSP that involves the closing and surveillance of pest pathways that affect these two genera (amongst others) would present governments and community groups with an opportunity to sustainably fund an ongoing program of activities with industry financial support. For the forest sector the proposed NFPSP would provide the benefits of diagnostic support from government agencies and additional surveillance capacity in urban and peri-urban areas through engagement with local government and community stakeholders.

Overall the NFPSP aims to mitigate the risks of exotic forest pest incursions into Australia and facilitate early detection and successful eradication efforts to reduce the rate of exotic forest establishments. This will be to the benefit of all Australia's forest types and forest stakeholders.

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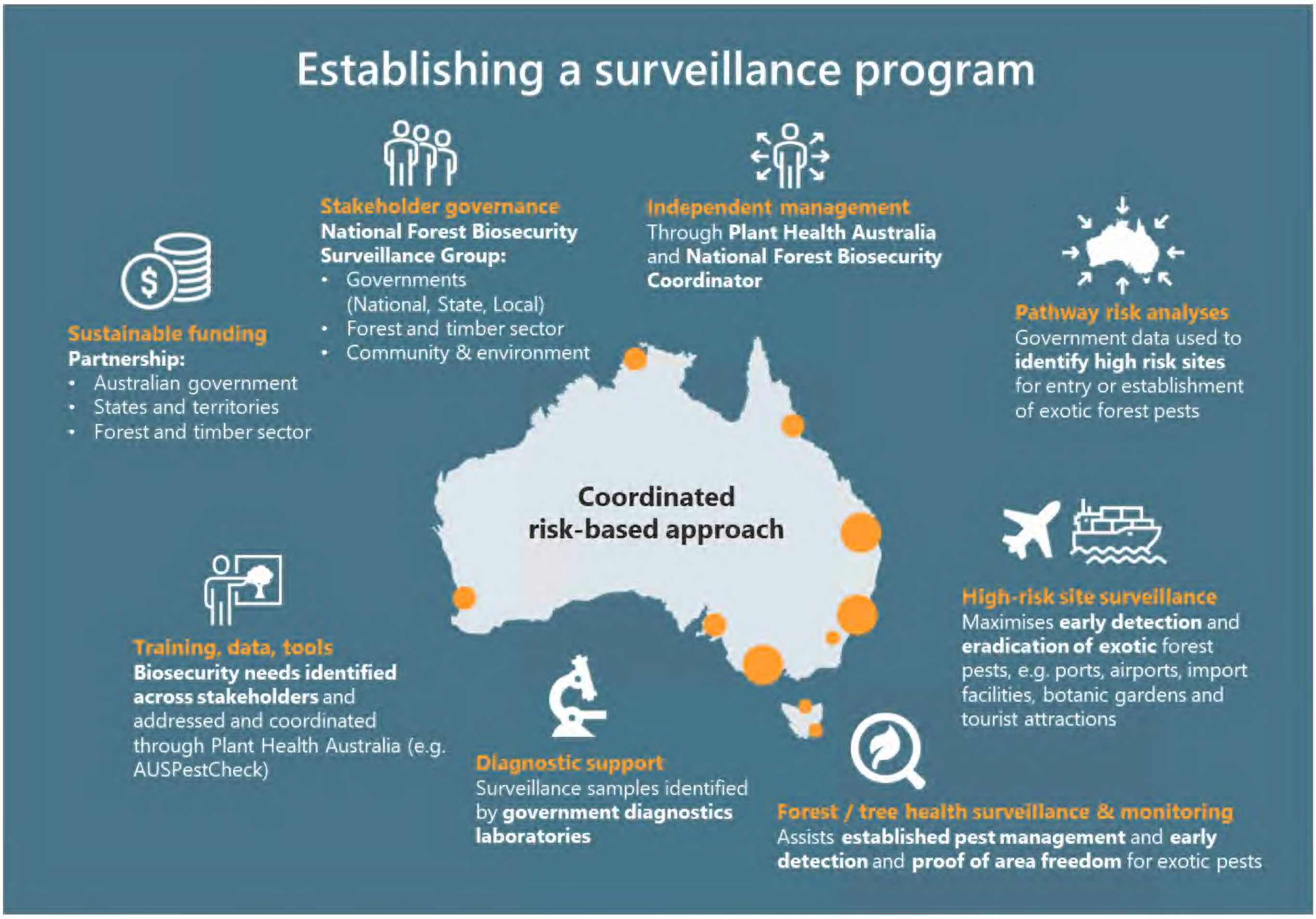

Establishing a surveillance program

Stakeholder governance
National Forest Biosecurity Surveillance Group:
- Governments (National, State, Local)
- Forest and timber sector
- Community & environment

Independent management
Through **Plant Health Australia** and **National Forest Biosecurity Coordinator**

Sustainable funding
Partnership:
- Australian government
- States and territories
- Forest and timber sector

Pathway risk analyses
Government data used to **identify high risk sites** for entry or establishment of exotic forest pests

Coordinated risk-based approach

High-risk site surveillance
Maximises **early detection** and **eradication of exotic** forest pests, e.g. ports, airports, import facilities, botanic gardens and tourist attractions

Training, data, tools
Biosecurity needs identified across stakeholders and addressed and coordinated through Plant Health Australia (e.g. AUSPestCheck)

Diagnostic support
Surveillance samples identified by **government diagnostics laboratories**

Forest / tree health surveillance & monitoring
Assists **established pest management** and **early detection** and **proof of area freedom** for exotic pests

Figure 3: Key components of a proposed National Forest Pest Surveillance Program. Different sized circles represent that surveillance efforts and activities would vary based on risk of entry and establishment across Australia, bigger circles represent more effort.

Myrtle Rust (*Austropuccinia psidii*) poses unprecedented challenges for plant conservation and recovery

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It is nearly nine years since the first detection of Myrtle Rust disease in Australia. Three hundred and fifty eight Australian native plant taxa are now recorded as hosts of the disease, 16% of our native Myrtaceae. Only about 3% of Australian Myrtaceae screened for susceptibility have failed to sustain infection, although this does not necessarily indicate susceptibility in the field. The host list will grow as field records accrue, as more species are tested, and if the pathogen invades potentially suitable areas in South Australia (SA) and Western Australia (WA).

Among the 358 known hosts, four are rapidly declining towards extinction as direct result of Myrtle Rust. Forty one more species are known or suspected to be in serious decline at least on a regional basis, although systematic monitoring is still lacking for most. Some ecosystems are at risk. The host range of the Myrtle Rust pathogen, *Austropuccinia psidi* in Australia includes most of the East Australian genera, but with wide variation in susceptibility and resistance between, and sometimes within, species.

Austropuccinia psidii is fully established in moist vegetation types along the NSW and Queensland coasts east of the Great Escarpment and north to Cape York, in the Torres Strait islands, and parts of the Northern Territory. In Victoria and Tasmania, it remains known only in cultivated situations and nurseries. It is unlikely to be a problem in drier areas *e.g.,* west of the Great Divide. Myrtle Rust remains absent from SA and WA, and domestic biosecurity arrangements apply to those States. It is not eradicable by any known means in the eastern States.

In a rare win, Lord Howe Island (LHI) appears to have eradicated an outbreak detected in October 2016 – final monitoring to confirm this is still pending. The LHI Board undertook vigorous pre-arrival preparation, with which the ANPC was proud to assist. The outbreak was detected very early, while still confined to non-indigenous garden species. Lord Howe Island however remains vulnerable to re-infection by airborne spores from the mainland, or by human vectors.

The single strain of *A. psidii* present in Australia has proved capable of infecting 106 native eucalypts, 22 from 'natural' infections (wild or in open cultivation). With three possible exceptions the impact appears to be mild. However, field survey of eucalypt susceptibility is inadequate, particularly for seedling and re-sprout life stages. The remaining 84 eucalypt hosts are from inoculation screening only. The ultimate impact of this strain of *A. psidii* on eucalypts in the wild is not yet predictable. A major biosecurity concern for Australia is that two other strains, so far confined to South America, are eucalypt-associated there, and probably responsible for the major economic losses and costs to the plantation eucalypt industry in South America since the 1940s (the disease is known there as Eucalyptus Rust).

Australian and New Zealand responses to Myrtle Rust

New Zealand has only about 30 native Myrtaceae species, some of great Maori cultural significance, plus a significant industry based on the exotic Feijoa. New Zealand has implemented a national approach with open communication, a wide range of community stakeholders including Maori interests, and has invested around $NZ 24 million on research and other activity relevant to environmental and cultural aspects of the problem (up from the $NZ 13 million reported at our November 2018 conference). New Zealand has made a precautionary 'threatened' listing for all native Myrtaceae, with projected de-listing for those that prove to be disease-tolerant.

Australia, after nine years and with 2,253 Myrtaceae species, has no coordinated national response, piecemeal research, no systematic monitoring, and no preparation for a long-term effort towards species recovery. On the most generous interpretation of environmental relevance, and including several research projects on primarily commercial native species, Australia's investment amounts to about $AU 4.3 million. Indigenous engagement has been minimal, largely limited to far North Queensland and the NT. Such spending is dwarfed by the amounts routinely spent on agricultural plant diseases.

Two Australian sources of research funding have however been important in laying a basis for understanding the environmental impacts. A small set of Commonwealth Government programs have provided about $AU 2.7 million, about $500 thousand of it directly relevant to biodiversity conservation. The Plant Biosecurity Cooperative Research Centre (PBCRC, now discontinued) played the most crucial role, funding basic work on biodiversity impacts (just under $1 million).

An additional bureaucratic problem for the Australian response to Myrtle Rust (and some other emerging threatening processes) is that in most jurisdictions, 'threatened species' investment is strictly limited to legislatively 'listed' entities, with little or no expenditure on unlisted entities even if they are known to be in steep decline. Most species worst-affected by Myrtle Rust were not previously listed as threatened. Listing processes have not kept pace with the impact of the pathogen. Three species have recently been listed as Critically Endangered in New South Wales (two of them from ANPC nominations lodged in April 2016), and actions and funding for them under the NSW 'Saving Our Species' program are now (February 2019) under consideration. None of the worst-affected species are EPBC-listed yet, precluding any direct allocation of Commonwealth threatened species funding.

New South Wales recognised 'Exotic Rusts on Myrtaceae' (short title) as a Key Threatening Process in 2011. A Draft Strategy for this KTP is in late draft stage as at February 2019; investment levels are yet to be determined.

Austropuccinia psidii falls within the ambit of the Commonwealth's 2013 catch-all listing of 'Novel biota and their impact on biodiversity' as a Key Threatening Process (KTP) under the *EPBC Act*. This national KTP included 'mortality, habitat loss and degradation caused by pathogens' as one concern. However, it does not provide specific advice or prioritisation of effort relating to Myrtle Rust. Nor do the associated non-statutory *Threat Abatement Guidelines* for this KTP. No other subordinate instruments that might do so have yet been developed. A 2013 nomination for a specific 'myrtaceous rusts' KTP was not progressed by the Commonwealth on the basis that the Novel Biota KTP provided adequate coverage.

Scaling up investment is essential, but political traction has been lacking. Much of the national communication process has been carried by an unofficial, un-auspiced, and un-funded network of scientists and conservation managers. An evolving consensus on vital conservation actions was recognised by the PBCRC and the Commonwealth's National Environmental Science Program (NESP), which in 2017-8 jointly funded a comprehensive *Review of Environmental Impacts* (Makinson 2018a) and a *Draft Action Plan* for Myrtle Rust (Makinson 2018b) – both now available on the ANPC website (http://www.anpc.asn.au/myrtle-rust/). These provide a framework for priority conservation actions, should appropriate levels of investment be made.

Difficult options

For the species in steepest decline from Myrtle Rust, we have almost missed the boat. At least four have declined catastrophically, and these and probably several others now produce little or no fruit (the rust attacks new seasonal growth). Many of the 45 priority species have seeds known or likely to be storage-intolerant.

For species of uniformly extreme susceptibility, with no known disease-tolerant genotypes, and a high rate of decline, there are limited management options and a rapidly narrowing window of opportunity. Such options as do exist for longer-range recovery, are entirely dependent on urgent salvage of as much representative germplasm as possible, and long-term *ex situ* conservation with a view to eventual breeding (or manipulated introduction) of resistance traits, then seed-orcharding and eventual re-establishment of resistant genotypes in the wild. Cases include *Lenwebbia* sp. 'Main Range', and the formerly common Native Guava (*Rhodomyrtus psidioides*) and Scrub Turpentine (*Rhodamnia rubescens*).

A larger set of priority species show variable susceptibility (high overall, but with more disease-tolerant genotypes in some populations), and somewhat slower rates of decline. *Melaleuca quinquenervia*, the foundation species for many east-coast wetland systems, is one example. For such species, large-scale germplasm capture is again essential, in quantities that will enable the selection of disease-resistant lineages from as many local populations as possible. These could then be bulked up to reinforce *in situ* survivors in their home populations, or to replace locally extinguished populations. This also requires close tracking of declines and of *in situ* natural selection of resistance traits. In some cases, it may prove possible to rely entirely on natural selection of disease-tolerant genotypes.

For yet other species with slower rates of decline, precautionary germplasm capture will still be required, with tracking of resistance genetics, and augmentation actions as needed.

These levels of germplasm collection and conservation use are unprecedented in Australia, and will require an expansion of investment in seedbank and seed research facilities, and support for dispersed and disease-protected sets of live plants for those species with storage-intolerant seed. Australia has the expertise and infrastructural capability to support this, it just needs to be scaled up.

But germplasm capture simply keeps future options open (there are none without it). The nature of the Myrtle Rust threat, for species where susceptibility and decline far outstrip natural selection processes, means that uncomfortably interventionist forms of conservation will need to follow.

Ex situ selection and breeding (or even engineered transfer) of resistance traits is technically feasible. The South Americans have been breeding rust-resistant commercial eucalypts for decades via normal silvicultural methods, informed by advanced genetics. However this course of action for *conservation* purposes, including eventual 're-wilding', entails issues – ecological, logistic, ethical, and cultural – that do not apply to commercial situations. A far larger germplasm base is needed to capture local variation and compensate for genetic bottlenecking in the breeding process. The aim would be to reintroduce genotypes as close as possible to those of original populations, but with better disease tolerance.

Resistance breeding for reintroduction is also challenged by the absence of commercial imperatives and investment, and the few global precedents for plants (there are rather more for animals). One of the best conceptual summaries of the complex issues is provided by Jacobs *et al.* (2013), for the case of the formerly keystone species American Chestnut (*Castanea dentata*) in North America. Many aspects of that paper are relevant to the discussion that must now occur in Australia, not least the need to build a social consensus, including Indigenous interests and values, right from the start.

There are uncomfortable choices to be made, but when the alternative is passive acceptance of extinctions, we need to begin the process. The conservation sector must draw on the experience and technical knowledge of the biosecurity and plant health sector to meet the threat of Myrtle Rust and other exotic plant pathogens yet to come. Both sectors will need to help drive the cross-over.

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News from the Australian Seed Bank Partnership

Reflections on Theme 6 – Do you need a safe deposit box? The importance of *ex situ* seed conservation in translocation

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The Australian Seed Bank Partnership was pleased to support the 12th Australasian Plant Conservation Conference and the launch of the 3rd edition of the Translocation Guidelines. It was wonderful to see so many from across the Partnership involved in the development of the conference and guidelines, and I congratulate those involved. Presented here are my very brief reflections on Theme 6.

Leek Orchids vs Extinction: A New Hope

It was great to see the ANPC support the work of students at last year's conference with Marc Freestone receiving one of three travel grants in recognition of his PhD project. Marc's work with the ANU and the Royal Botanic Gardens Victoria is leading to a better understanding of the challenges faced when trying to propagate *Prasophyllum* spp. from seed.

Damian Wrigley giving Theme 6 Plenary. Photo: Nathan Emery

Marc's preliminary findings are already providing the orchid community with a working example of successful germination efforts using asymbiotic germination media for leek orchids. Further exploration into the relationship between the genus and the soil mycorrhizae will hopefully assist in preventing multiple extinctions across this threatened genus. With research dedicated to understanding its germination requirements we may soon see significant advances in leek orchid conservation throughout Australia.

WA's safe deposit box

Even if germinating some seed is not complicated, the efforts required to ensure their viability can be significant. Building and maintaining viable collections requires commitment and determination over the longer-term. An inspirational example of this came from Anne Cochrane, formerly of the Threatened Flora Seed Centre in Western Australia. Over the past 25 years, WA has seen a transformation in seed banking of threatened flora from an initial focus on *Phytophthora*-affected species in a small, modified demountable to a broadened remit of targeting all legislatively listed threatened taxa in a world-class facility not far from the southern banks of the Swan River. Anne's experience and insights presented delegates with a definitive message that careful planning and flexibility are key to ensuring seed collections remain diverse, viable and of a suitable size for translocations. Most importantly, Anne demonstrated that a proactive approach to conservation is critical. And what can be more proactive for securing the broadest genetic representation of Western Australia's native flora than a well-targeted and sustained seed banking program. Thank you Anne for your contribution to the sector and for so generously sharing your knowledge with the broader conservation community.

Playing to our Strengths

Continuing with the notion of sharing knowledge and thinking carefully about how to approach flora conservation, Bec Stanley from the Auckland Botanic Gardens provided a positive example of how collaborating with the community is supporting successful *in situ* and *ex situ* conservation efforts throughout New Zealand. Botanic gardens are in a unique position to connect with local, national and international communities on the conservation challenges facing native flora. Bec showed that existing horticultural expertise throughout the broader gardens network is enabling complex conservation challenges to be tackled head-on. Conservation messaging can be cleverly integrated into garden design, providing the opportunity to reveal the breadth of experience in propagation and seed conservation. This knowledge is then shared with restoration groups throughout the community. The strong focus on partnerships in Bec's talk was encouraging. No single garden or conservation organisation has all the answers. It is important that we continue to collaborate and share our combined knowledge to raise awareness of the conservation community's efforts and why something as small as seeds can be so important.

Marc Freestone. Photo: Nathan Emery

Seed Resources for Restoration

Despite much communication, collaboration and long-term commitments to seed conservation from both individuals and organisations, the sector continues to struggle to attract sustained financial investments. It is common for many across the sector to rely on a patchwork of funding from governments, donors and a variety of environmental grants. Unfortunately, inconsistent and small-scale funding opportunities present challenges for growing the sector and indeed creating a viable seed supply market. Paul Gibson-Roy reminded delegates of these challenges, drawing comparisons to the American experience, where broad-scale restoration and translocation projects benefit from significant funding from the philanthropic and government sectors. These investments have leveraged further investment in a sustained and viable market that supports a substantial restoration sector. Paul's advocacy for a larger and more economically viable seed sector is important. It also reminds me of how significant our achievements are in light of the relatively small investment profile we have in Australia.

Securing currency in the bank, and how to grow it

Despite our best efforts, some collecting trips result in relatively small deposits to seed banks. However small, high quality collections that possess broad genetic variability can be utilised successfully in restoration and translocation projects. The example of *Santalum acuminatum* presented by Caroline Chong highlighted that even with a small collection, significant conservation and cultural outcomes can be realised. Recently the National Seed Bank at the Australian National Botanic Gardens overcame dormancy and cultivation challenges to successfully propagate a small number of seedlings that will be returned to Uluru-Kata Tjuta National Park to augment the existing local genotype pool. Caroline emphasised the importance of ensuring that the collections' data is properly curated and that this information be accessible by the broader conservation and Indigenous community. Conservation projects that seek to secure better biodiversity outcomes are reliant on the availability of accurate collection and research data and it is on all of us to ensure we make this data available.

Cassinia tegulata survival linked to fire

Implementing beneficial management techniques comes down to sharing the knowledge and data we create. Bryan Haywood did just that following his discovery of how fire can influence the regeneration of *Cassinia tegulata* in a previously revegetated site. Bryan illustrated how even with carefully planned revegetation efforts there is no guarantee that recently revegetated populations will thrive. Following careful consideration of the local conditions Bryan and his team identified fire as a tool that could reduce competition from introduced grasses and sedges. Ongoing management of weeds and sustained monitoring led to the emergence of hundreds of new seedlings. While *ex situ* conservation seed banks do play a vital role in making material available for restoration works, it is often the soil seed bank that requires consideration in regards to supporting sustainable populations, post-revegetation. By better understanding the impacts of competition on seedling recruitment and the tools that can reduce their impact, *Cassinia tegulata* may be on its way to a promising future.

Editors' note: You can read about Bryan's work in detail in his article in this issue of APC.

Responses of Nitre Goosefoot (*Chenopodium nitrariaceum*) to simulated rainfall, and depth and duration of experimental flooding

Speaking of the future, PhD student Will Higgisson from the University of Canberra presented on a project exploring the germination response of *Chenopodium nitrariaceum* to experimental flooding. The project simulated inundations to determine ideal flood regimes by testing the impacts of soaking, and short- to long-term flooding. The results identified that short-term flooding resulted in better germination than long-term flooding events which is consistent with the observed flood plain distribution for the species. The practicalities of managing environmental flows is complicated and field trials are likely to provide valuable additional data. However, this project has delivered substantial results that can lead to better management decisions and inform future experimental design. It is important to acknowledge that seeds were collected as part of the project but that seed bank facilities assisted in the preparation of seed for this experiment. To me this highlights the role of seed banks as functioning laboratories with experienced scientists continuing to support students throughout the country.

It is encouraging to see the multitude of applications for seed presented across one conference. A clear takeaway message for me was that continued endeavours to secure better genetic representation across our collections is paramount to supporting better environmental decisions. It is therefore on all of us, as funders, collectors and users of seed to continue supporting the expansion and maintenance of our native seed collections so that they better reflect the known genetic diversity of Australia's native flora and are available for use in restoration and translocation projects for many years to come.

Acknowledgements

The Author would like to acknowledge the presenters and co-authors from Theme 6 for contributing to the discussion on *ex situ* seed conservation (Theme 6 Presenters – Mark Freestone, Anne Cochrane, Rebecca Stanley, Caroline Chong, Paul Gibson-Roy, Bryan Haywood, Will Higginson).

ANPC workshop reports

Feeling SEEDY in the Hunter

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A native vegetation and seed field day, and direct seeding demonstration, was held on Sunday 25 November 2018 on the property "Springdale" in the Upper Hunter Valley. The day was organised by Ashley Bacales as part of the Hunter Councils *Nine Valleys Wildlife Corridors Project* with the assistance of Hunter Regional Landcare Network, Martindale Creek Catchment Landcare, Hunter Local Land Services and the Australian Network for Plant Conservation and funded through the NSW Environment Trust.

Around two dozen people attended at Martindale Hall and "Springdale" to look at and discuss restoration and revegetation techniques outlined by the ANPC's Martin Driver. These included hand and light hand machine methods and a demonstration of a vehicle towed direct-seeder supplied and operated by Steve Field of Fields Environmental Solutions. Seed for the demonstrations was donated by Greg Major of Future Harvest.

Participants learnt how direct seeding of native feed and fodder species, fencing and appropriate grazing management can create a landscape of abundance and enhance the natural and financial values of their properties. Salt bush, wattles, native grasses – these plants not only cope best with tough soil and climatic conditions, they provide highly palatable feed for farm animals.

The importance of sustainable, genetically and species-diverse local seed supplies and seed supply systems to support direct seeding projects was discussed as the first step in being able to cost-effectively get regionally driven large-scale corridor restoration projects going. While direct seeding is regularly used in local mine site rehabilitation and in other regions, it has rarely been used in the Hunter on private or community diverse species restoration projects. However, with trials under local conditions, direct seeding could represent a cost effective means of revegetating larger areas including Local Land Services Travelling Stock Route restorations. The participants also inspected some regenerating species components of Weeping Myall woodlands, and discussed the importance of planning, fencing and grazing management to retain and extend these species with direct seeding.

The opportunity for future related workshops on seed harvesting, seed production areas, seed processing and treatment and other establishment or management techniques were proposed from the day. Steps are also underway by Paul Melehan to establish an Upper Hunter Landcare native seed supply network to support future projects.

Direct seeding demonstration at "Springdale Farm". Photos: Paul Melehan

WA Threatened Plant Translocation Workshop

LUCY COMMANDER

A hugely successful WA Threatened Plant Translocation Workshop was held for 51 participants on Thursday 14th March 2019 at the Department of Biodiversity, Conservation and Attractions (DBCA) in Kensington, Perth.

Twelve speakers from DBCA joined ANPC project manager Lucy Commander in presenting various aspects of the Translocation Process. Margaret Byrne, Director Executive Director, Biodiversity and Conservation Science started the morning by giving an introduction. Lucy gave an overview of recently published Third edition of the ANPC's Guidelines for the Translocation of Threatened Plants in Australia, which was produced with funding from the National Environmental Science Programme's Threatened Species Recovery (TSR) Hub.

Colin Yates spoke about ecology of threatened flora followed by Juliet Wedge who highlighted the importance of taxonomy. Andrew Crawford spoke on collecting and storing seeds, Shane Turner described seed biology and nursery propagation, then Eric Bunn explained micropropagation and cryobanking.

ANPC committee member and leader of the TSR Hub's project 4.3 David Coates spoke about the importance of considering genetics when planning translocations. Melanie Smith explained WA policy, legislation and approvals process and Tanya Llorens provided tips on how to prepare a translocation proposal, as well as giving a sneak peek of the new translocation proposal, which is based on the template provided in the ANPC Translocation Guidelines. It's wonderful to see that the Guidelines are already assisting the improvement of Translocation processes in WA.

Speakers at the WA Threatened Plant Translocation Workshop, from left to right: David Coates, Eric Bunn, Lucy Commander, Melanie Smith, Carole Elliott, Siegy Krauss, Juliet Wedge, Leonie Monks, Colin Yates, Andrew Crawford and Tanya Llorens. Photo: Helena Mills

Colin Yates. Photo: Leonie Monks

Leonie Monks, who has been implementing translocations for over two decades, spoke on implementing and assessing translocations. Carole Elliott and Siegy Krauss gave case studies based on their research, on translocation in the mining sector, and the long-running *Grevillea scapigera* translocation.

Andrew Crawford led a tour through the Threatened Seed Centre, which supports many WA translocations. We finished the day with a lively panel discussion, to talk about issues in threatened plant conservation and translocation practice. Several current and former ANPC committee members were in attendance at the workshop. Many people travelled from regional areas across the state to attend the workshop, and there was ample time for networking. Selected presentations will be available on the ANPC website.

Thanks to DBCA for their support for the workshop, and the TSR Hub for their support in producing the Translocation Guidelines.

ANPC member profile

Rob Scott

Corresponding author: robscott@naturelinks.com.au

What is your current position?

Director of Naturelinks Landscape Management, a corporate member of the ANPC

What projects are you working on at the moment?

Setting up a Victorian branch of AABR the Australian Association of Bushland Regenerators and preparing to host a Biodiversity Management Software forum for land managers in the Melbourne region.

Rob Scott. Photo: Marjorie Michael

How did you end up working in plant conservation?

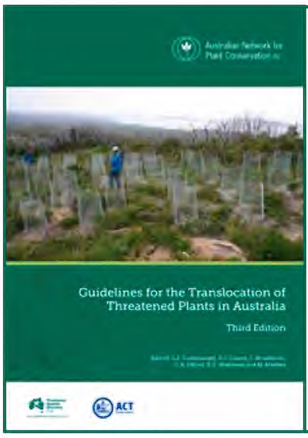
I started working in horticulture when I left school, as well as going to Queensland Field Naturalists field days. When I became aware of the concepts of indigenous plants in the mid 1980's I moved to that field, firstly running a seed collection and plant recovery project on the Melbourne basalt plains region, then working for St Kilda Council setting up an indigenous nursery and local plant conservation and restoration program as well as helping set up a local environment group.

What is your favourite plant and why?

I love the River Red Gum for its majesty, beauty, age, its ability to host such a myriad of functions and life and stamp its character on the landscape.

Why do you think the ANPC network is important and what do you see as our priorities?

The work of ANPC in communicating information about issues, research and projects being carried out around Australia is vital to me as someone involved in the management of biodiversity.


Guidelines for the Translocation of Threatened Plants in Australia
Third Edition
ACT

Guidelines for the Translocation of Threatened Plants in Australia

The ANPC's brand new third edition is on sale now! Step-by-step information on how to do best-practice translocations, improve translocation success and contribute to preventing plant extinctions.

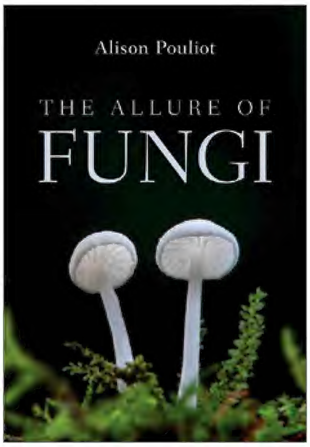
Third Edition 2018 | Eds L.E. Commander, D.J. Coates, L. Broadhurst, C.A. Offord, R.O. Makinson and M. Matthes. Australian Network for Plant Conservation, Canberra.

For more information and to order, go to http://www.anpc.asn.au/translocation

Book reviews

Allure of Fungi

280 pages, 245 x 170 mm, colour photographs, September 2019, CSIRO Publishing.
ISBN: 9781486308576. Price AU $49.99 (Paperback).



Having spent 1000 days in the forest thinking about and photographing fungi, Alison Pouliot has put out a book documenting a range of perspectives on this topic. In a combination of text and photographic essays (separate in definite sections), Alison lures us into the often mysterious world of fungi. She passionately explores fungal complexities and curiosities in a book that is not a reference or coffee table book nor field guide, more an enthusiastic documentation of our knowledge in this field.

The book covers a lot of diverse topics and has thought provoking sections to draw the reader; like 'disco in a cowpat' – who wouldn't want to read this? The organisation of the book takes a bit of time to get your head around and may not be as logical as some would like. For example, the taxonomic organisation of fungi and 'what makes a mushroom?' appears in chapter 6, rather than at the start, but this is just a comment not a criticism.

The human-fungus relationship is explored with stories of farmers, fungal enthusiasts and mycologists that the author visits in person (lamingtons in hand). This personal touch makes this book a great read and adds a nice dimension. Alison highlights the lack of acknowledgement of fungi in Australian environmental management and conservation. Foraging is linked back to conservation with the section 'On morel grounds', which documents the protection of fungi in the Kooyoora State Forest after commercial morel hunters began to visit the area.

The book also explores the habitats where fungi grow; from the desert to subterranean areas, to the more typical habitats of moist forests and woodlands. This section discusses some fungal hosts, and therefore their distribution, and how we are improving our knowledge in this area.

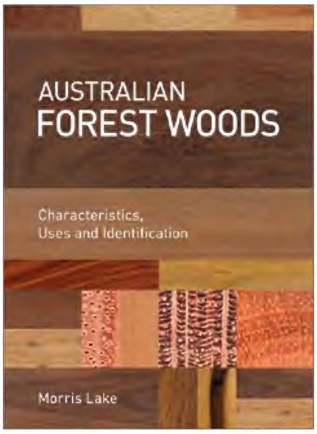
The language around fungi was especially interesting, since the words we choose affect the way fungi are seen and understood. Alison explores the origin and use of the word 'mushroom' and the negative associations of fungi in the English language. She points out that the more accurately fungi are written and talked about, the more likely they will increase in importance.

Last, but not least, the macrophotography at the end of each chapter makes the book worth picking up alone. Alison has used a small depth of field to her advantage by highlighting miniscule parts of a fungal fruiting body, mycelia, various fungal surfaces and beautiful lichens.

Michele Kohout

Australian Forest Woods. Characteristics, Uses and Identification

Morris Lake, x+218pp., colour illustrations, 2019, CSIRO Publishing. ISBN 978-1-4863-0778-4. Price AU $69.95 (Hardback).



This beautifully presented book a companion to 'Australian Rainforest Woods, Characteristics, Uses and their Identification', contains ready and interesting information – primarily for people interested in trees, wood enthusiasts in Australia and for international audiences interested in the unique diversity of Australian trees and woods.

By way of introduction, aspects of plant classification are presented for the angiosperms and gymnosperms from an evolutionary context. The bulk of the book contains well illustrated treatments of 129 Australian forest trees. Species are described one per page at least. Standard information is provided including: the botanical and usually the trade name, synonymy where relevant, origins of the botanical name, botanical family name, other names by which the trees and woods are known, and geographical distribution. A description of the tree's botanical field characteristics with useful and often interesting comments and anecdotes are given about the tree's historical and local significance. In each case, the wood is described with information about the colour, grain appearance, density, durability, drying properties, shrinkage characteristics and common uses. Sometimes potential uses, the latter exemplifies the versatility the Australian species rarely provided. Tree habit and the appearance of smooth side-grain (backsawn or occasionally quartersawn) of the wood are illustrated with colour photographs. In addition to the information provided, material from interesting anecdotal, personal experience is included for several woods, *e.g.,* dead finish (*Archidendropsis basaltica* formerly known as *Albizia basaltica*), narrow-leaved red iron bark (*Eucalyptus crebra*).

A particularly unique aspect of this book is the inclusion of the end-grain photographs of skillfully sanded and polished specimens by Jean-Claude Cerre from France. Each of the woods including two softwoods (Conifers) and the remaining set of hardwoods (Angiosperms) featuring 46 species of eucalypts (*Eucalyptus*). Each species is represented by a low power (15x) and a high power (x90) colour macrograph of exquisite quality, the high-power images are close to rivaling transverse microscope sections. However, in the reviewer's opinion, the low power images are more useful and informative for macroscopic wood identification. Instead of the high-power image, another low power image of the species showing variation may have been beneficial. As an aside, it would have been useful to indicate somewhere the actual size of the low power image to enable scaling of features. Unfortunately, there are a few peculiarities with the editing, printing or photography of the macro images: *Casuarina* spp. (Casuarinaceae) (p.176 and 178) are placed under the banner of Gymnosperms with the softwoods, while the closely related *Allocasuarina* spp. (same family) are correctly placed under the Angiosperms. There are a number of other errors that will hopefully be addressed in future editions. Further, a note about the colour of the side-grain timber images: It seems that something has gone astray with either the photography or the printing process. The colour of many species illustrated lacks 'red' – images exhibit a greenish cast. Unfortunately, this is a detraction given the purpose of the book as a reference source. Interestingly, the various crafted items shown alongside are by and large representative of the wood colour. Viewing the images under a warm tungsten light helps to bring out the rich red colour of the red timbers, *e.g.,* jarrah, red mahogany.

In continuation, scrutiny is required with the use of terminology: wood rays occasionally referred to as medullary rays is archaic. The use of "gum veins" instead of kino-veins in eucalypts is strictly inaccurate; while that may be common parlance among bushies and timber workers it is inaccurate in wood technology. Additionally, the discussion about the "Contender for the heaviest wood in the world" (p. 32) is convoluted and uses technical references which are difficult to unravel, *e.g.,* basic density of the cellulosic compounds! Does that refer to the basic density of the bulk wood or purely wood compounds derived from saccharides excluding the polyphenolic lignins? Arguments presented about the moisture content of the illustrated block are confusing and unconvincing without further detail. The wood property data should have been referenced specifically, otherwise it is difficult to ascribe reliability. Occasional references to interlocked grain imparting "some strength" to the wood (e.g., *Acacia cana*, p16.) are inaccurate unless clarified. Technically, while interlocked grain makes chopping wood more difficult, in the context of structural design for which wood strength usually refers, deviation of grain away from the axial direction reduces wood strength and stiffness. Finally, the author's vision of "The new future of wood identification" is admirable but is not realistic. From the reviewer's point of view and experience, cross-sectional images on their own are inadequate without microscopy. There is just too much overlap among the macro wood anatomical features, and while the approach may work for a disparate group of species, sadly the information is insufficient from macro cross-sections alone (no matter how sophisticated the AI pattern recognition might be) to facilitate identification of "Any given wood specimen" (p. 174). Finally, the book's title suggests that it can be used to facilitate wood identification is strictly inaccurate given that there is no key provided nor a list of commensurate features.

In summary, this book is worth pursuing for the reference information it provides, the rarer species and particularly for the Cerre images, but as an authoritative document, it needs to be used with care.

Jugo Ilic

News

NEWS FLASH!

Find out more about the ANPC's Translocation Guidelines and the role of the ANPC in the newly published short videos now available at **http://www.anpc.asn.au/translocation_guidelines_review/**

Calls for emergency action plan as myrtle rust pushes plants to extinction

Experts say some members of 'enormously important' myrtle family could be extinct within five years, with others to follow. Australia must roll out an emergency national response to an invasive plant disease that is rapidly pushing at least four plant species to imminent extinction, experts have told Guardian Australia. A draft emergency action plan for the fungal disease myrtle rust proposes that a rapid collection of seeds and plant material needs be mobilised before several species disappear altogether. Botanist Bob Makinson, vice-president of the Australian Network for Plant Conservation, has coordinated the action plan with input from about 90 experts around the country. He says the pathogen could result in at least four species becoming extinct within five years – *Lenwebbia* sp. 'Blackall Range', *Lenwebbia* sp. 'Main Range' and *Rhodamnia rubescens* (scrub stringybark, brush turpentine, or brown mallet wood), *Rhodomyrtus psidioides* (native guava) – with others to follow. **https://www.theguardian.com/environment/2019/jan/24/calls-for-emergency-action-plan-as-myrtle-rust-pushes-plants-to-extinction?CMP=share_btn_link**

Myrtle Rust in Australia

A draft Action Plan

May 2018

Australian Government

National Environmental Science Programme

CRC PLANTbiosecurity

Dave Coates. Photo: Nathan Emery

David Coates: A dedication to Australia's plantlife

ANPC Committee member and past president Dr David Coates is currently working with the Threatened Species Recovery Hub (TSRHub), leading *Project 4.3 Threatened Plant Translocations* which is developing criteria for measuring the success of plant translocation projects, and reviewing outcomes of past plant translocations and research in order to develop best practice guidelines for plant translocation in Australia (including the ANPC's new Translocation Guidelines). Read about what inspired him to dedicate his life to Australian plants, including field trips through south-west Western Australia with its remarkable plant species richness and many issues associated with habitat loss and vegetation change. **http://www.nespthreatenedspecies.edu.au/news/david-coates-a-dedication-to-australias-plantlife-tsr-hub-researcher-profile**

Cuttings: Plant news from around Australia

Editors' note: News excerpts are clipped from a diversity of sources. To read the articles in full follow the links attached to each clipping. The views expressed in these articles are those of their authors and do not necessarily represent the opinion of the ANPC.

Remote Ranges

Josh Byrne visits the Helen and Aurora Range (known as Bungalbin by the Traditional Owners) 400km east of Perth in the Southern Cross region. He meets amateur botanist and WA Wildflower Society member Brian Moyle, who has spent many years working to protect this rare banded-ironstone landscape and its Gimlet gum (*Eucalyptus salubris*) woodland from mining. He tells us why the area needs protecting.
https://www.abc.net.au/gardening/factsheets/remote-ranges/10343146

Audit of unprecedented mangrove dieback

James Cook University (JCU) scientists investigating an unprecedented mangrove dieback in the Gulf of Carpentaria three years ago are surveying the area to see how well it has recovered – and the early signs aren't good. Dr Norman Duke's Mangrove Research Hub at JCU's Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER) is co-leading the Investigations as part of a project supported by four National Environmental Science Program Hubs. The JCU team has joined forces with fellow experts from Charles Darwin University (CDU) and the Northern Territory Government to perform field surveys in the aftermath of the 2015-2016 dieback event. Dr Duke says that while more than 1500 kilometres of shoreline were impacted and more than 8000 hectares of mangrove trees were lost with this event, the effects varied in different places from around 100% losses to approximately 10-20% damage. "The aim is to quantify the difference in impacts as well as the extent of the recovery three years on," he said.
https://www.nespnorthern.edu.au/2018/10/12/audit-of-unprecedented-mangrove-dieback/

Spectacular display of native flannel flowers captures imaginations in NSW coastal town

They are one of Australia's most recognisable and loved native flowers, and this spring they have burst into bloom in a nature reserve on the mid-north coast of New South Wales. Some locals are saying that the display of flannel flowers in the Kattang Nature Reserve, south of Port Macquarie, is the most impressive they have seen in decades. National Parks and Wildlife Ranger in the Hastings Macleay region, Mandy Smith, said the wildflowers were breathtaking. "It's just almost like this carpet of wild, white, beautiful flowers, just standing up facing the sun, just a joy, it's wonderful to see," she said.
https://www.abc.net.au/news/2018-10-13/flannel-flowers-bloom-on-mid-north-coast/10359594

Aftermath of the Kings Park bushfire sees stunning wildflowers rise from the ashes

Eight months ago, the northern end of Kings Park was a depressing sight. More than 16 hectares of the bushland in Perth's world-famous stretch of parkland was destroyed by a deliberately-lit fire. But thanks to a wet winter, the blackened area is now covered in flowers which have not been seen in that region of the park for decades. The bare open ground left in the fire's wake has been populated by a collection of plants that only bloom after a fire. "There is a dormancy that some species have," said Steve Easton, the manager of biodiversity conservation for the Botanic Gardens and Parks Authority.
https://www.abc.net.au/news/2018-11-04/aftermath-of-kings-park-bushfire-sees-wildflowers-bloom/10457996

'They could run their fingers through the soil': the role of Aboriginal agriculture in curtailing deforestation

At the end of October, the WWF released their *Living Planet Report 2018,* which found that Australia is one of the world's deforestation hotspots, the only developed nation to make the list. The report went as far to compare the east coast of Australia to the situation in the Amazon, a 'deforestation front'. Another report by researchers from the University of Queensland, released right after the WWF report, demonstrated that just 20 countries contain 94 per cent of the world's remaining intact ecosystems, and that more than 70 per cent is in just five countries, including Australia, giving us more responsibility to protect what's left of the country's wild places.
https://www.australiangeographic.com.au/topics/science-environment/2018/11/they-could-run-their-fingers-through-the-soil-the-role-of-aboriginal-agriculture-in-curtailing-deforestation/

Plants Red Hot List: No surprises, no regrets

Threatened plants tend to receive less attention than threatened animals, even though they make up 72% of all threatened species listed under national law. To draw attention to our species in trouble, a TSR Hub project has identified the top 100 Australian plant species at greatest risk of extinction. We've also identified the 21 types or groups of plants under greatest threat. Jen Silcock from The University of Queensland talks about the findings. **http://www.nespthreatenedspecies.edu.au/news/plants-red-hot-list-no-surprises-no-regrets**

Project aims to develop roadmap for a sustainable bush medicine industry

The recent commercialisation of the Kakadu plum, as a super food and skin product, has many looking for the next big thing in Australian native plants. Now an academic-industry collaboration aims to develop a blueprint for a sustainable bush medicine industry with long-term benefits for Indigenous Australians. **https://www.abc.net.au/radionational/programs/lifematters/project-aims-to-develop-roadmap-for-a-sustainable,-bush-medicin/10488064**

Southern WA's new 4WD route from Perth to Albany risks dieback spread in vulnerable forests

The intense popularity of a new four-wheel-drive route weaving through Western Australia's southern forests has been overshadowed by a potential biosecurity risk. South Coast Natural Resource Management (NRM) is concerned the trail may further spread a plant pathogen capable of killing the state's most vulnerable native species if poorly managed. The recently-opened trail has been a 10-year project by the WA 4WD Association and has garnered enough public interest to crash the association's website. Dieback is caused by the plant pathogen *Phytophthora cinnamomi*, which kills plants like banksias, jarrah and grass trees, by attacking their root systems. There is no known cure and it affects more than 40 per cent of the region's native plant species and half of its endangered species. **https://www.abc.net.au/news/2018-11-16/4wd-track-in-wa-could-be-a-biosecurity-risk/10502466**

Australia is the real home of mistletoe

Viscum album more commonly known as the European mistletoe, with its white berries and yellow-green leaves, is the species people are most familiar with. What people may not know is that Australia is home to more species of mistletoe than anywhere else in the world. We have over 90 different species. The difference between Aussie mistletoe and the European variety, of which there's only one species, are the families they belong to. "Mistletoe plants belong to two different families… traditionally the Loranthaceae, and the Viscaceae," explains Dr Russell Barrett, a botanist from the Royal Botanic Garden Sydney. "Australia has many species of Loranthaceae, but only a small number of Viscaceae". **https://www.australiangeographic.com.au/topics/science-environment/2018/11/australia-is-the-real-home-of-mistletoe/**

Banksias a worthwhile challenge for curators of new display at National Botanic Gardens

Banksias are one of Australia's most distinctive wildflowers. They were first planted on the site of the Australian National Botanic Gardens (ANBG) in Canberra in 1947. Soon they'll play a starring role in a new garden currently under construction to celebrate the ANBG's 50th anniversary in 2020. David Taylor, ANBG's curator of living collections, said the garden would showcase the variety of banksias while telling the story of their place in our landscape. **https://www.abc.net.au/news/2018-11-21/new-banksias-for-australian-national-botanic-gardens/10513706**

Kakadu plum plan aims to take a bite out of lucrative global medicine industry

Skin products and health drinks may soon be ripe with a quintessentially Northern Territory ingredient if a proposal to commercially harvest Kakadu plums gets off the ground. Traditional owners of Kakadu National Park are hoping to use their land to cultivate inroads into the traditional medicine market — an industry they have estimated to be worth up to $115 billion globally. The ambitious plan by the Gundjeihmi Aboriginal Corporation to wild harvest the plums — a small, green native food with proven health benefits due to its high levels of vitamin C — was released on Tuesday for comment. **https://www.abc.net.au/news/2018-11-21/kakadu-plum-plan-aiming-bite-lucrative-global-medicine-industry/10516544**

Sowing the seeds of sustainability

Everyone assumes it was mind-blowing but no one can be exactly sure how early settlers felt when they first came across Victorian grasses and wildflowers stretching as far as the eye can see. With less than one per cent of the Western Basalt Plains grasslands remaining, we only ever glimpse them in fragments. In a cruel twist it was these floriferous landscapes' best bits – their graceful growth and billowing openness – that paved the way for their downfall. First they were seen as readymade farmland. Then, they proved to be the perfect setting for housing estates, factories and shopping centres. **https://www.smh.com.au/entertainment/sowing-the-seeds-of-sustainability-20181130-h18jsi.html?fbclid=IwAR3Ix4ZHzuB-3MDXtj0szGGGOZE8b4a0epxip97iwbmOorkUbisj7FSbOwo**

Invasive species and habitat loss our biggest biodiversity threats

A desire to avoid more extinctions is one of the drivers behind new research by the Threatened Species Recovery Hub which has identified invasive species as the no. 1 threat to Australian biodiversity with habitat loss a close second. Lead researcher Stephen Kearney from the University of Queensland said Australia was rich in unique biodiversity but has had a poor track record since European settlement. "We are one of only 17 'megadiverse' countries globally, Australia contains over 12% of the world's vertebrate species. Over 4 out of 5 of our species are found nowhere else on earth," said Mr Kearney. "Australia has also recorded 90 extinctions since European settlement, 36 plants, 27 mammals, 22 birds, four frogs and an earthworm, and extinction rates per decade are not improving. **http://www.nespthreatenedspecies.edu.au/news/invasive-species-and-habitat-loss-our-biggest-biodiversity-threats**

People from all over the world are sending emails to Melbourne's trees

Melbourne gave 70,000 trees email addresses so people could report on their condition. But instead people are writing love letters, existential queries and sometimes just bad puns. **https://www.abc.net.au/news/2018-12-12/people-are-emailing-trees/10468964**

Discovery of plant thought extinct highlights importance of flora conservation

It was pure curiosity that lead botanist Libby Sandiford to rediscover a plant species that had not been seen for almost 90 years. Shoved up against the side of a busy highway in Cranbrook, 90 kilometres north of Albany in Western Australia, Ms Sandiford noticed a plant that was slightly different. "The reason I collected it was that I thought 'I actually don't know this plant', and I want to know what it was. "So I had no idea that it was a presumed extinct plant at the time." When she ran her small specimen through an identification process it came back as the *Acacia prismifolia*, a plant last seen in the Stirling Range in 1933. Andrew Crawford, a research scientist with the WA Department of Biodiversity, Conservation and Attractions, said it was an incredible find. "It's an amazing feeling — no one had recognised what it was for 90 odd-years," he said. **https://www.abc.net.au/news/2018-12-13/seed-bank-holds-the-forgotten-conservation/10610418**

Less-famous living fossil: Botanist fine with 'iconic' Wollemi Pine overshadowing his own rare tree find

If you have never heard of the Springbrook Leatherwood tree it may be because it was discovered around the same time as another living fossil — the headline-grabbing Wollemi Pine. Botanist David Jinks was walking through a remote section of the Springbrook National Park, west of the Gold Coast, in 1993, when he came across an unusual looking rainforest tree. "I never expected to discover a tree," he said. Dr Jinks collected samples and testing revealed it was an undiscovered species of *Eucryphia*, an evergreen plant that is only found in Australia and South America. "It's one of the few trees we have that link us directly to the supercontinent Gondwana," said the botanist. **https://www.abc.net.au/news/2018-12-22/living-fossil-discovery-overshadowed-by-the-famous-wollemi-pine/10615860**

Volunteers beat odds to remove weed from remote beaches in Tasmania

In an operation organisers describe as adventure volunteering a group is flying into the remote World Heritage Wilderness Area in Tasmania to spend up to a month ridding beaches of sea spurge. The weed harms shore bird nesting sites and pushes native plants out of the environment. **https://www.abc.net.au/radio/programs/am/volunteers-beat-odds-to-remove-weed-from-beaches-in-tasmania/10681028**

Flowers can hear bees, new research suggests

Flowers can hear and respond to the sound of buzzing bees, which spurs them to produce a more sugary nectar, new research has found. The findings from the study, recently published in *bioRxiv*, have the potential to change our understanding of the role of sound in the life cycle of flowers. Evolutionary theoretician Lilach Hadany from Tel Aviv University tested her theory using evening primroses (*Oenothera drummondii*), exposing them to the playback sound of buzzing bees and sounds of a similar frequency. The primroses responded within three minutes to the playback sound of buzzing bees, increasing their sugar concentration by up to 20 per cent. **https://www.australiangeographic.com.au/news/2019/01/flowers-can-hear-bees-new-research-suggests/**

Most coffee species at risk of extinction due to climate change, scientists warn

If you're one of Australia's 11-million-plus coffee drinkers, you probably started today with a cup of caffeinated liquid gold. You might also want to sit down before reading this.

And maybe grab another latte while you still can. Of the 124 wild coffee species worldwide, UK researchers have declared at least 60 per cent of them in danger of dying out. But wild coffee isn't what I drink, you say? Well ...The wild relative of the world's most popular coffee species, *Coffea arabica*, is an endangered species. **https://www.abc.net.au/news/science/2019-01-17/coffee-facing-extinction-climate-change/10713870**

'We are clearly losing the fight': scientists sound alarm over invasive species

Invaders are a greater threat to native species than climate change, land clearing and energy production, experts say. “We might be the last people on earth to take a sample of an Australian native guava in flower,” says botanist Rod Fensham, as he studies a small cluster of white flowers. The guava (*Rhodomyrtus psidioides*) is heading for extinction, says Fensham, of the University of Queensland – but not because of land clearing or climate change. Instead it’s the relentless march of the invasive fungi myrtle rust that will cause its demise. Myrtle rust is just one example of the invasive pests – weeds, animals and pathogens – that are cutting a swathe through Australia’s unique native flora and fauna. **https://www.theguardian.com/environment/2019/jan/21/we-are-clearly-losing-the-fight-scientists-sound-alarm-over-invasive-species**

Waterhole springs back to life as Indigenous rangers tackle buffalo damage in Arnhem Land

It has only been six months since feral buffalo were fenced out of Weemol Spring in central Arnhem Land, but there has already been a stunning transformation. The once degraded Northern Territory wetland has sprung back to life, with native plants and animals rapidly recolonising its bare and muddy creek banks. Indigenous ranger group, Mimal Land Management, fenced the spring after local Dalabon traditional owners raised concerns about damage being caused by feral buffalo, donkeys and horses. Women's ranger coordinator, Julia Salt, said the rate of recovery had taken everyone by surprise. **https://www.abc.net.au/news/rural/2019-01-21/waterhole-springs-back-to-life-as-buffalo-fenced-out/10731350**

'Gobsmacking': Forests need decades to recover from bushfires

To Canberra's west, among the Brindabella Ranges, forest soils are still potentially recovering from the effects of a devastating bushfire. That bushfire may not be the deadly 2003 Canberra bushfires but the Black Friday fire which saw huge sections of the ACT, along with Victoria and NSW, go up in smoke on January 13, 1939. New research from the Australian National University has shown that forest soils take several decades to recover from the effects of bushfires or logging, more than half a century longer than scientists originally thought. By studying alpine soil samples in Victorian mountain ash forests, researcher Elle Bowd and her colleagues Sam Banks, Craig Strong and Professor David Lindenmayer discovered the effects of bushfires which took place as far back as 80 years ago were still being felt in forest soil. **https://www.canberratimes.com.au/national/act/gobsmacking-forests-need-decades-to-recover-from-bushfires-20190121-p50spd.html**

Biggest land-for-conservation deal aimed at heading off irrigators

One of the most important wetlands in the Riverina has been saved from potential conversion into cotton or rice farms in what's being claimed as the largest purchase of private land for conservation in Australia's history... The purchase will protect almost the entire Great Cumbung Swamp, home to 131 bird species and more than 200 plant species. **https://www.smh.com.au/environment/conservation/biggest-land-for-conservation-deal-aimed-at-heading-off-irrigators-20190122-p50sxe.html**

The march toward extinction

A new study has found that over 50 Australian plant species face extinction within a decade. We find out which plant species are under threat and explore the possibilities for recovery. Associate Professor Rod Fensham, Director, The Ecology Centre, University of Queensland. **https://www.abc.net.au/radionational/programs/blueprintforliving/the-march-toward-extinctinction/10743796**

Gum trees and the fight against global warming

Just as the world grapples with the effects of climate change – fiercer and more frequent bushfires, droughts, floods and freak storms – Australia is doing its darndest to cut down more trees. Forests are disappearing so fast in NSW and Queensland that WWF International has put Australia on its list of global deforestation hot spots – the only one in the developed world – while koala populations continue to be decimated through habitat loss. Climatologists say one of the easiest and cheapest ways to reduce carbon emissions is to preserve forests; deforestation accounts for 18 per cent of global emissions, far surpassing vehicles and aircraft combined, according to the Climate Council. **https://www.smh.com.au/environment/climate-change/gum-trees-and-the-fight-against-global-warming-20190122-p50suu.html**

Conferences and courses

Taxonomy for Plant Conservation – Ruia mai i Rangiātea

24–28 November 2019, Wellington, New Zealand

The Australasian Systematic Botany Society and the New Zealand Plant Conservation Network are proud to announce our joint conference Taxonomy for Plant Conservation – Ruia mai i Rangiātea in November 2019.

Attending this conference is a must do for anyone who is passionate about science and conservation of native plants in New Zealand and Australia.

This conference will be held at Wellington's premier venue, the Museum of New Zealand Te Papa Tongarewa.

- Get up to date with our stimulating and comprehensive range of speaker presentations
- Explore Wellington's forests and rugged coastlines on our field trips
- Network with people involved in a wide variety of plant conservation work
- Discuss and learn about a range of issues at our workshops
- There will be opportunities to tour the Te Papa herbarium and Otari Native Botanic Gardens

CONTACTS AND INFORMATION

Key conference organisers: Rewi Elliot (NZPCN) and Heidi Meudt (ASBS).

To contact the conference organisers email:
plants2019nz@gmail.com

Updates: follow us on our Facebook page:
ASBS NZPCN Wellington 2019

Conference website:
https://systematics.ourplants.org/

OUR PROGRAMME IN BRIEF

Sunday 24 November

Workshops at various locations; welcome reception at Te Papa; after-hours access to new Taiao-Nature exhibition

Monday 25 November

First day of presentations; public lecture in the evening

Tuesday 26 November

Second day of talks; conference dinner in the evening on Te Marae at Te Papa

Wednesday 27 November

Field trips at various locations

Thursday 28 November

Final day of talks; conference closes; public lecture in the evening

A calls for abstracts and registration fees will be available in April 2019.

CONFERENCE SPONSORSHIP

Participating as a sponsor at the conference will lead you to a range of people involved in plant conservation, taxonomy and related fields and demonstrate your level of support and commitment to native plant conservation.

Our 2019 ASBS-NZPCN joint conference has several sponsorship packages available, providing sponsors with a choice of exposure related to financial commitment.

The 2019 ASBS-NZPCN joint conference can provide your organisation with:

- Exposure at a premier conference devoted to leaders in plant conservation work and scientific research.
- Time to network with industry colleagues and key decision makers.
- A cost effective way to reinforce your organisation's brand to a relevant audience.
- Access to a broad network of potential partners from the public and private sector.
- Marketing opportunities including online visibility and associated conference material.

We therefore invite you to discuss with us options available to tailor-make a sponsorship package that best suits your organisation.

ABOUT THE AUSTRALASIAN SYSTEMATIC BOTANY SOCIETY

Our 2019 conference will be in partnership with the Australasian Systematic Botany Society (ASBS). With over 300 members, the ASBS is an incorporated association of people with professional and amateur interests in Australasian systematic botany. The aim of the Society is to promote the study of plant systematics in Australasia.

Plant systematics includes taxonomy and nomenclature, and is the science that unravels the relationships and evolutionary history of the flora. It provides the framework for all comparative biology and is essential for the identification and conservation of threatened species, the management of native vegetation, and the detection of naturalised species.

ASBS website: www.asbs.org.au
Email: secretary.asbs@gmail.com

ABOUT THE NEW ZEALAND PLANT CONSERVATION NETWORK

The NZPCN was established in 2003 and has since grown to more than 800 members worldwide. The Networks vision is that "the rich, diverse and unique native plant life of New Zealand is recognised, cherished and restored".

Our biennial conferences are highly regarded as the best place to meet people who are passionate about plant conservation and to network and collaborate on shared issues and challenges. Our website along with our newsletter, Trilepedia, are leading sources of information about native plants and their conservation in New Zealand, receiving over 800,000 page views per year.

NZPCN website: www.nzpcn.org.nz
Email: info@nzpcn.org.nz

Other conferences, courses and events

Updates available at http://anpc.asn.au/other_conferences_and_events

Botanic Gardens Day Australia and New Zealand - 26 May 2019

Botanic gardens, arboretum and gardens in Australia and New Zealand will celebrate the vital work botanic gardens do for plant conservation. Botanic Gardens Australia and New Zealand Inc. is expecting the 4th Botanic Gardens Day to be the biggest event yet, with over 100 gardens and arboretum set to be involved.
http://events.r20.constantcontact.com/register/event?oeidk=a07eg3u1e4be4438f76&llr=fh7pmmjab&showPage=true

2019 Australian Biosecurity Symposium - Gold Coast, QLD, 12-13 June 2019

Animal Health Australia (AHA), the Invasive Species Council (ISC) and the Centre for Invasive Species Solutions (CISS) are excited to announce the inaugural 2019 *Australian Biosecurity Symposium*. Our Symposium will provide the ideal platform for diverse cross sectoral discussion, where new concepts are introduced, ideas are shared and tested, advice is sought and given, and new partnerships built. The Symposium theme is preventative biosecurity and focuses on: Preventative biosecurity practices; Research, innovations and outside-of-the-box thinking; and the exchange of knowledge and ideas across the biosecurity collective - agriculture (animals and plants) invasive species, weeds, wildlife, aquatics and the environment.
https://www.biosym.com.au/

8th Biodiversity Across the Borders Conference - Ballarat VIC,14 June 2019

With the theme 'Climate Change and Future Landscapes', this one-day conference aims to communicate new ecological research to natural resource managers, the research community and those with an interest in better environmental management. The free all-day conference will be held at the Mt. Helen campus of Federation University Australia. The keynote address will be delivered by Professor Leslie Hughes (Pro Vice-Chancellor (Research Integrity and Development) and Distinguished Professor of Biology at Macquarie University). The focus of the 2019 conference will be: Restoration and management of ecosystems in a changing climate; Threatened species: solutions under climate and landscape change; Managing water ways and wetlands in a changing climate; and Connecting people and nature: values, ethics, communication, and practice. For natural resource managers, it is an excellent opportunity to learn about emerging applied research outcomes and what they mean for you. For researchers it is a great way to communicate your work in a way that can make a real difference. Biodiversity Across the Borders continues to build and strengthen collaborative networks so as to enhance both research and land management into the future.
https://federation.edu.au/schools/school-of-health-and-life-sciences/research/conferences/biodiversity-across-the-borders

2019 Orchid Conservation Symposium - Melbourne VIC, 18-19 June 2019

17% of all of Australia's Nationally threatened flora are orchids, with the majority of these species found in south eastern Australia, making orchid conservation a national priority. Hosted by the Royal Botanic Gardens Victoria (RBGV), the two-day workshop will bring together community groups, practitioners and scientists in a workshop to engage and educate the community on current conservation research in the field and to increase collaboration between the community, practitioners and scientists. Increased knowledge sharing and network building through collaborations will reduced the risk of vulnerable or near threatened species becoming endangered.
https://www.rbg.vic.gov.au/science/projects/orchid-conservation

Nature City Seminar - Perth WA, 26-28 June 2019

An innovative seminar to improve WA's capacity to better manage, enhance, design and connect with nature in urban areas. A 2-day seminar and 1-day field trips to showcase the latest research and best practice case studies from across WA's urban areas. The main themes for the Seminar and Field Trips are management, conservation, restoration and enhancement of nature, and connecting people with nature. These themes will cover urban bushland, parkland, benefits of nature to human health, and biophilic design. Call for sponsorship now open. Contact drlucycommander@gmail.com for more information.
https://www.bushlandperth.org.au/event/nature-city-seminar/

20th NSW Weeds Conference – Newcastle NSW, 26-29 August 2019

Are you working to manage and eradicate weeds in Australia? The 20th NSW Weeds Conference is a premier event for NSW weeds officers, researchers, market and industry analysts, government officials and policymakers working towards better weed management across the country. The conference will unite more than 250 weeds management experts in the beautiful beach-side city of Newcastle, Australia. Weeds are a serious threat to Australia's native flora and fauna and add pressure to our economy. Recent technologies, policies and innovations are helping us manage weeds more effectively – but more work is needed. This conference provides an opportunity for the NSW weeds management community to showcase new research and ideas for controlling and eradicating weeds. It's a chance to network and build strategic partnerships and invest in a shared vision for our industry's future.
https://www.nswweedsconf.org.au/

WA State NRM and Coastal Conference - Perth WA, 1-4 October 2019

The 2019 State Natural Resource Management (NRM) and Coastal Conference will be held amongst the beautiful natural gardens of Edith Cowan University, Joondalup. A highly regarded WA event that has been held regularly since the 1990s, the Conference will focus on maximising networking opportunities with an interactive program including workshops, tours, engaging conference sessions and open space sessions. The theme for the conference is 'Our Coast | Our Land – Striving Together'. The theme aims to inspire delegates to make transformational changes together that improves and protects our natural environments and creates healthier communities.
https://www.nrmandcoastalconference.org.au/

BGANZ Congress 2019 - Wellington NZ, 20-23 October 2019

Plants from the past: plants for the future. Plants have brought Australasian Botanic Gardens together though BGANZ every 2 years since 2003. They have canvassed a range of roles and perceived roles for botanic gardens. They have been about education, conservation, their roles in communities and any number of shades of these themes. 2019 returns to basics - it is all about the plants. Science, education, recreation, conservation, community outreach – they are all dependent on plants.
https://www.confer.nz/bganz2019/

ESA19: the 2019 Conference of the Ecological Society of Australia - Launceston TAS, 24-29 November 2019

'Ecology: science for practical solutions'. Ecology is the science of interactions among all forms of life and the abiotic environment they inhabit, and in turn, change and shape. Applications of ecology are all around us everyday, in natural resource management, forestry, fisheries, agriculture, water production and conservation biology. These applications demonstrate the importance of ecology in seeking to understand and explain our Earth, and how humans can better co-exist with nature in an increasingly anthropogenically-modified environment. This provides the theme for this conference: how the science of ecology can contribute to developing and implementing solutions for our planet in the throes of a biodiversity crisis and a changing climate. Ecological science is fundamental to informing policy but the next generation of practising ecologists will need to work more closely with economists, political scientists, historians, human geographers and social scientists to develop ecologically sustainable practices. Registrations open 10 June 2019.
https://www.esa2019.org.au/

22nd Australasian Weeds Conference - Adelaide SA, 25–29 October 2020

In October 2020 the Weed Management Society South Australia will host the 22nd Australasian Weeds Conference at the Adelaide Oval. This biannual Australasian event comes to Adelaide once every 14 years, and is an opportunity not to be missed.
http://wmssa.org.au/events/

Research round up

COMPILED BY KIRSTEN COWLEY

Centre for Plant Biodiversity Research, Canberra. Email: Kirsten.Cowley@csiro.au

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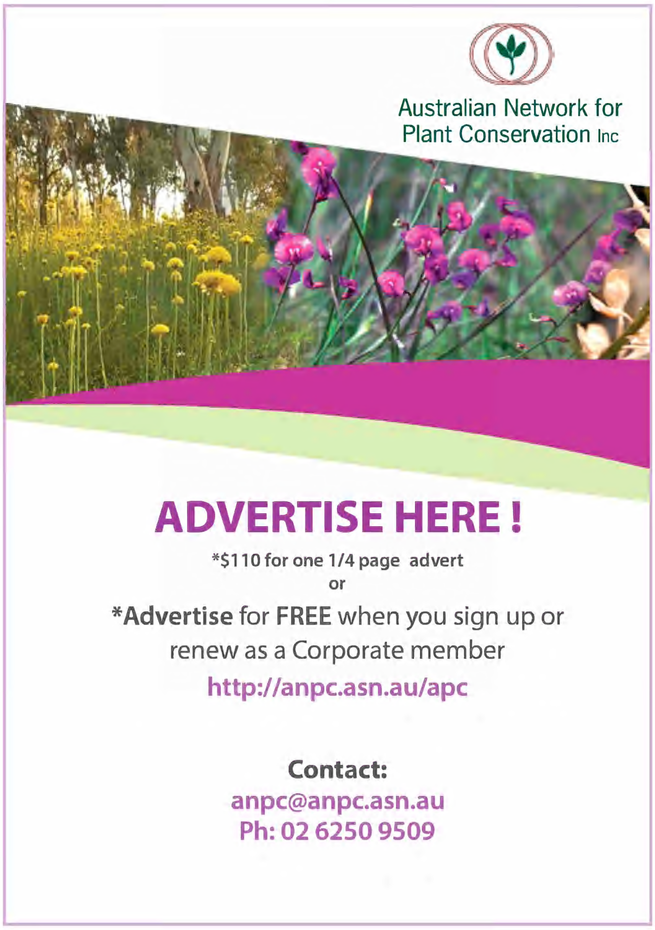
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Naturelinks, VIC

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Australian Network for
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Please donate to help save Australia's unique native plants!

Many of Australia's native plants are threatened and we need your help to promote and improve their conservation. Donate to the ANPC today and support our network of people working in plant conservation. Donations of $2 or more to the ANPC are tax-deductible. See **https://www.anpc.asn.au/donate/** for more information.

The end of financial year is fast approaching!

The ANPC brings together plant conservationists from all walks of life to inform and inspire each other in our efforts to save Australia's plants, especially those threatened with extinction.

Our high priority projects for 2019 include:

- promoting the new ***Guidelines for Translocation of Threatened Plants in Australia***.
- holding further **Threatened Plant Translocation workshops**.
- launching our **National Seed Survey Report**.
- improving the **supply of native seed in NSW**.
- seeking funding for updating our **Germplasm Guidelines**.
- Stage 2 of the **Bring Back the Banksias project**.
- our **two orchid conservation projects** with Royal Botanic Gardens Victoria.
- planning the 2020 **13th Australasian Plant Conservation Conference** (APCC13).

Your donation will help the ANPC improve conservation efforts for threatened plant species and raise community awareness.

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Complete the online donation form here at **https://www.anpc.asn.au/donation-form/**